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Pre-service physics teachers' conceptual understanding of kinematics graphs in Tanzania

Beni Mbwile[1], Jonathan Hegwa Paskali[2]

[1]*Mkwawa University College of Education, University of Dar es Salaam, Tanzania, Corresponding author, benimbwile1@gmail.com, ORCID ID: 0000-0002-8885-2165*
[2]*Tanzania Institute of Education, Tanzania, ORCID ID: 0009-0003-2148-9175*

ABSTRACT
Tanzanian secondary school students have consistently performed poorly in the topic of motion in a straight line, which involves kinematics formulas and graphs. Despite instruction, many struggle to plot and interpret these graphs, largely due to limited conceptual understanding among both learners and teachers. This study examines the conceptual understanding of kinematics graphs among pre-service physics teachers in selected Tanzanian teacher training colleges. Using a mixed-methods approach with a sequential explanatory design, the study involved 225 pre-service teachers from two colleges. Data were collected through a validated kinematics graph concept inventory and interviews, then analyzed using SPSS version 22, Excel, and thematic analysis technique. The findings revealed five key challenges: difficulty interpreting slopes of graphs that do not start at the origin, representing stationary objects on the graph, calculating total distance when motion involves both forward and backward directions, interpreting areas under acceleration-time graphs, and converting between kinematics graphs. These challenges underline the need for learner-centred teaching strategies to enhance students' conceptual understanding and performance. The study recommends that physics educators in Tanzania recognize and address these specific difficulties when teaching kinematics graphs to students.

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Introduction

The topic of kinematics is significant in learning physics and mathematics because it consists of concepts that build the foundation required by students to learn the next concepts (Amin et al., 2020; Planinic et al., 2013). An inadequate understanding of kinematics concepts may result in poor understanding of further concepts (Manurung et al., 2018). According to Ole & Gallos (2023), kinematics is one of the fundamental topics in physics which need to be covered by students in many countries. Some kinematics concepts include position, displacement, speed, velocity and acceleration. According to Amin et al. (2020), kinematics concepts tend to be presented as formulas and displayed in the form of graphs. Kinematics graphs have velocity, position and acceleration as the ordinate and time as the abscissa (Beichner, 1994). The knowledge of kinematics graphs plays an important role in graph constructions that are not necessarily related to kinematics. Researchers in mathematics, science and educational psychology use kinematics graphs to explore learners' graphing abilities (Susac et al., 2018). Graph constructions, presentation and interpretation are integral to teaching and learning physics (Beichner, 1994). Through graphs, the use of complex formulas can be minimised and some equations can be obtained from graphs.

However, many students have difficulties with kinematics graphs even after learning relevant concepts. The study by McDermott et al. (1987) revealed two kinds of difficulties learners encounter with kinematics graphs. The difficulties include challenges in connecting graphs to physical concepts and misconceptions in connecting graphs to the real world. In addition, Beichner, (1994) pointed out seven misconceptions learners were facing when dealing with kinematics graphs. These included learners seeing the graph as a picture, confusion between slope and height, confusion of variables, difficulty in determining the slope of the line, confusion of area under kinematics graphs, and confusion between area, slope and height. Also, Hernández et al. (2021), Phage et al. (2017), & Núñez et al. (2022) found that very few students could associate the slope with velocity or acceleration. Furthermore, Antwi (2015) reported four difficulties learners had with kinematics graphs: difficulties in describing the shapes of kinematics graphs, calculating slopes from curved graphs, interpreting areas under kinematics graphs and converting between kinematics graphs. Similarly, they have difficulties in separating the meanings of position, velocity, and acceleration versus time graphs (Antwi et al., 2018; Maries & Singh, 2016; Zavala et al., 2017).

In Tanzanian, kinematics graphs are taught to Form Two students with average ages of 13 and 14 years under the topic called motion in a straight line. Motion in a straight line is one of the physics topics in which candidates' performance in both Form Four and Form Two national examinations is low, hence negatively affecting the overall performance in physics (Mbwile & Ntivuguruzwa, 2023a, b). Results from the National Examination Council of Tanzania (NECTA) show that students' performance on the topic in Form Two National Assessments (FTNA) was weak for the past five years (NECTA, 2017-2021). For example, from 2017 to 2021, the top score was 20.9% in 2018. Results are considered to be good, average and weak if their average percentage lies in the interval of 65-100, 30-64, and 0-29, respectively (NECTA, 2018).

The weak performance of candidates in the topic of motion in a straight line contributes to their poor performance in physics. For example, results from the basic education statistics in Tanzania indicate that the average performance in the Certificate of Secondary Education Examination from 2017 to 2019 was below 50% (Ministry of Education, Science and Technology, 2019, 2020). Weak performance in the topic of motion in a straight may be attributed to directly or indirectly to students' and teachers' difficulties in interpreting kinematics graphs (Mbwile et al. 2023a). Also, since students' and teachers' difficulties are often comparable to other with similar characteristics (Mubarokah et al., 2018), pre-service physics teachers from training colleges may have similar difficulties. Little is known in the Tanzanian context about specific challenges learners, teachers and pre-service teachers face when working with the topic of motion in a straight line, specifically in kinematics graphs. According to Kirya et al. (2022), Mbwile et al. (2023b) & Mohammad et al. (2020), challenges facing learners on a specific area of the topic or subtopic can be identified by using assessment tool called concept inventory. Therefore, this study aimed to use the available kinematics graphs concept inventory to identify challenges facing pre-service physics teachers when working with kinematics graphs in teachers training colleges

Research Question

What could be the challenges facing physics pre-service teachers from teachers' trainging colleges when interpret kinematics graphs?

Methodology

Research Approach and Design

A sequential explanatory design was adopted during the process of data collection. This is a design in a mixed research approach whereby the outcomes of data collection in a quantitative research approach inform data collection methods in a qualitative approach (Bowen et al., 2017; Creswell & Clark, 2017). Thus, in this study, the outcomes from testing pre-service physics teachers were used to structure and administer interview questions to some of them.

Research Participants

The study sampled 225 pre-service physics teachers from two teachers' training colleges in Tanzania. Half of the respondents were first-year and the other half were second-year diploma pre-service teachers majoring in physics, education, and one more science subject. The average ages of respondents ranged from 21 to 23 years while 45 were females and 180 were males. To avoid selection bias, first-year and second-year pre-service teachers were randomly picked by using YES/NO cards. Pre-service teachers who picked NO cards were excluded from the test. Similar sampling was used to obtain participants for interviews whereby only pre-service physics teachers who sat for the test were considered for Interviews.

Instruments and Validation

The study used a validated physics teachers' concept inventory for interpreting kinematics graphs and interviews. A kinematics graphs concept inventory with set of 25 multiple-choice questions used for testing learners' understanding of kinematics graphs was adopted from one of the already published inventories (Mbwile et al., 2023a). Also, interview questions used to assess pre-service teachers' conceptual understanding of kinematics graphs more deeply were constructed by considering the outcome of test result analysis. Interview questions were peer-reviewed by two PhD physics students at the University of Rwanda and cross-checked by two physics experts found in Iringa-Tanzania. The kinematics graphs test as indicated in the Appendix section was given to 225 pre-service physics teachers to test their conceptual understanding of kinematics graphs. After analysis of test results, 20 pre-service physics teachers (10 from each teachers' training college) who sat for the test were involved in interviews. Interviews were conducted to understand the conceptions of pre-service teachers more deeply.

Data Analysis Procedures

Quantitative data were analysed by using Statistical Package for Social Science (SPSS) version 22 and Excel Sheet. SPSS was so useful in obtaining descriptive and inferential statistics such as mean score, standard deviation, frequencies of choice selection, and normality of the test. The Excel Sheet was used to compute marks of participants and displaying statistical charts. Qualitative data analysis was carried out by following six stages of thematic analysis (Braun & Clarke, 2006). The researcher had an opportunity to familiarise with data by reading and listening to recorded voices, followed by generating initial codes through data reduction for efficient analysis and then organising codes into broader themes. Thereafter, themes were reviewed through examination, defined and named to indicate what was interesting about the themes, and the final report about pre-service teachers' conceptual understanding of kinematics graphs was written by using themes that made a meaningful contribution to the research objective.

Ethical Considerations

The study adhered to ethical issues, including obtaining research permits from the University of Rwanda in Rwanda and the Ministry of Education, Science and Technology in Tanzania. Also, participants gave their consent for their willingness to contribute to the study by signing consent forms. Furthermore, sources of information were acknowledged by citing inside the main text and putting their bibliography in the reference section. Moreover, real names were avoided by using arbitrary coding instead. For example, X and Y were used for the sampled colleges while T1 to T20 represented pre-service physics teachers who participated in a focus group discussion.

Findings

The general performance of pre-service physics teachers when tested for conceptual understanding of kinematics graphs, revealed the mean, standard deviation, and distribution of scores using the Shapiro-Wilk normality test as indicated in Table 1 below.

Table 1

Mean, standard deviation, and Shapiro-Wilk normality test

Category	N	Mean	Standard Deviation	Significance	Normality test
Test	225	36.53	9.19	0.278	Normal Distribution

Table1 shows a p-value of 0.278 which means the test scores were normally distributed. Although the test was administered to learners who were taught kinematics graphs in previous years, a mean performance of 36.53 is below 50%. Pre-service teachers' mean performance below 50% despite learning the topic in previous years aligns with Beichner (1994) who found a mean score of 40% despite the prior exposure students had about kinematics graphs. Arguing along the same lines Setyono et al. (2016) showed that the ability of learners to interpret kinematics graphs was still low, with an average percentage of 48%. Also, the study by Amin et al. (2020) revealed the achievement of students in answering each kinematics graph question was 20.99 % and 11.91% for the highest and lowest performance respectively. The findings agree with NECTA (2019, 2020) indicating students' what level? performance on Motion in a straight-line topic (comprising kinematics graphs and formulas) in FTN was 11.7% and 12.5% in 2019 and 2020 respectively. These performances are lower than what was revealed from the findings. The difference may be attributed to the nature of the participants whereby teacher trainees were better compared to secondary school students.

Meanwhile, results from pre-service physics teachers' frequency of choice selections for each of the 25 test items and interviews were so useful in identifying challenges facing them on kinematics graphs. The revealed challenges include difficulties in interpreting the slope of the line graph which does not start from the origin, presenting the stationary position of the object on the graph, and calculating total distance when forward and backward directions are involved. Other challenges include difficulties in interpreting the area under acceleration time graphs, and converting from one graph to another. The summary of the frequency of choice selection for each of the 25 test items is indicated in Figure 1 below.

Figure 1

Pre-service teachers' frequency of choice selection for each question (N=225)

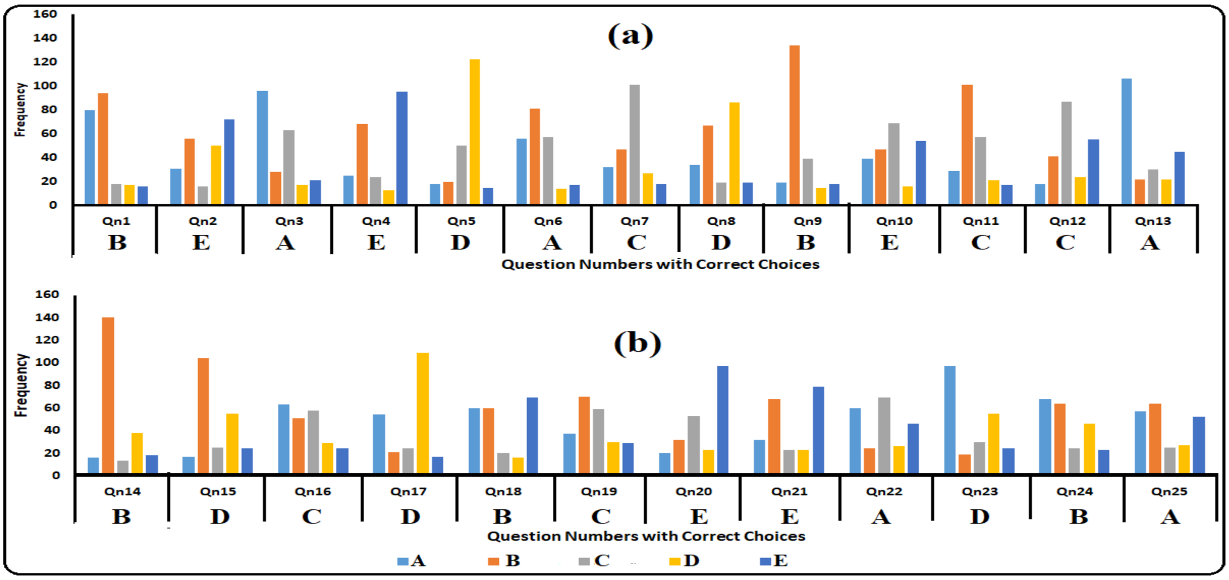


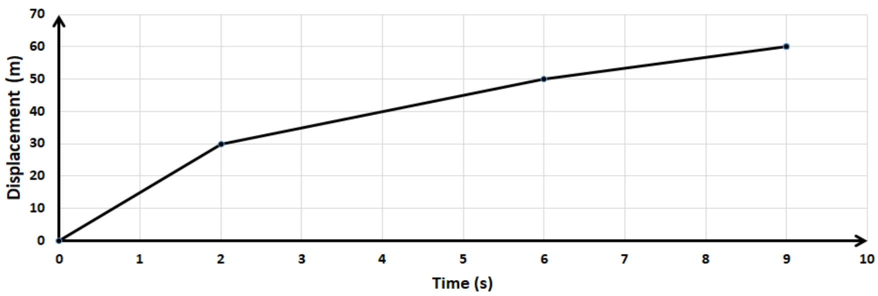
Figure 1 shows how 225 pre-service teachers selected multiple choices for all 25 questions. In each question, there was a correct choice and one or more distractors representing students' misconceptions. Identified challenges through frequency of choice selections and interviews are described in the following sub-sections.

Interpreting Slope

It was noted from test findings that pre-service physics teachers had difficulties interpreting the slope of line graph which does not start from the origin. Figure 2 below shows an example of a test item number 10 where pre-service teachers were asked to find the velocity of an object at a time (t) = 4 seconds.

Figure 2

An example of an item for testing slope



In the Figure 2 above (the Figure representing question 10), pre-service physics teachers were required to divide of the total displacement covered between time (t) = 2 seconds to t = 6 seconds with its corresponding time. The total displacement covered was 20 metres (50m-30m) and the corresponding time was 4 seconds (6s-2s). The division between displacement and time (velocity) is

5m/s. This velocity is constant at any point between 2 seconds and 6 seconds. However, the majority of pre-service teachers were dividing displacement-coordinate (40m) with time-coordinate (4s). The majority got 10m/s as a correct response instead of 5m/s.

Similarly, in question number 16, distractor A was more popular than the correct answer C because they were students were dividing vertical coordinate with horizontal coordinate instead of dividing total displacement with its corresponding time. The challenge was that, many pre-service teachers were assigning coordinate values directly to the slope which is valid only if the line representing slope starts from origin.

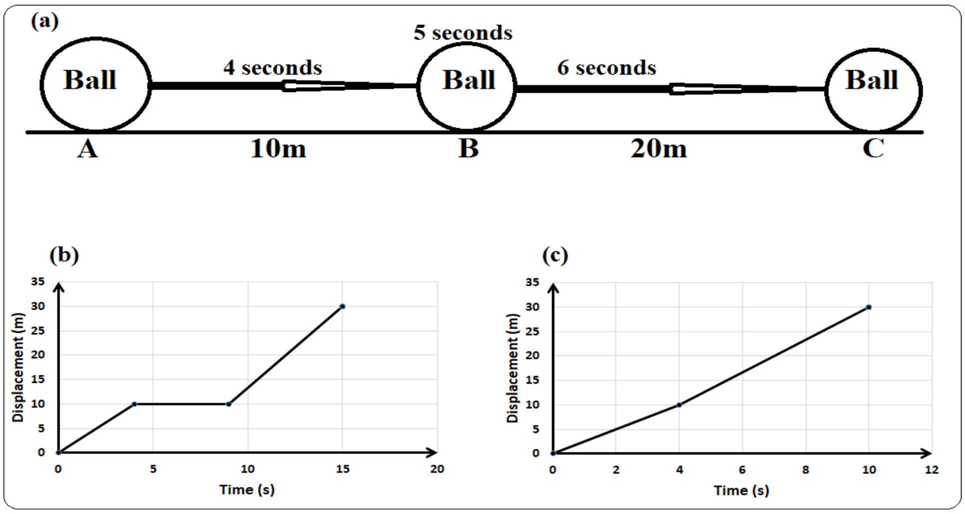
Findings from pre-service teachers' interviews supported findings from testing as 17 of 20 pre-service teachers had views of dividing displacement-coordinate with time-coordinate. For example, pre-service teacher T5 from Teachers' College X contended that "t*o get the velocity of a point, someone is required to read properly the coordinates of the displacement axis and that of the time axis. Thereafter, calculate the velocity (slope) of an object at a given time by taking the ratio of distance coordinate and time coordinate".* The quotation above signifies little understanding of slope concepts among pre-service physics teachers. These findings could be valid if the line which represents slope could start from the origin. It signifies the challenge pre-service teachers had with the slope of kinematics graphs.

Presenting the Stationary Position of an Object on a Graph.

Findings show that pre-service teachers had little understanding of stationary objects being presented on the position-time graphs. Although pre-service teachers were able to identify the stationary positions of the object on the already drawn graphs, results from pre-service teachers' interviews revealed the challenge of presenting the stationary position of an object on a graph. Figure 3a is an example of a test item where pre-service teachers during oral interviews were asked to present the position-time graph of a ball moving from point A to B for 4 seconds, stopping at point B for 5 seconds, and finally moving from B to C for 6 seconds. Many pre-service teachers (13 of 20) responded by drawing the position-time graph as indicated in Figure 3c below instead of 6b.

Figure 3

An example of item for presenting stationary objects and responses



In Figure 3 above, many pre-service teachers were drawing the wrong Figure 3c because were neglecting time spent by an object while at a stationary position. To draw the required graph as indicated in Figure 3b, they were required to use the time spent to cover the total displacement which was 30 meters plus the time spent when an object was at a stationary position. In contrast, many used only the time related to distance covered.

Furthermore, oral interviews revealed similar misconceptions as quoted from pre-service teacher T14 of Teachers' College Y who contended that *"if you want to draw a position-time graph, do not consider the time spent by the object when it was not moving. Thus, from the Figure we are given, only 10 seconds which comprises 4 seconds covered from A to B and 6 seconds covered from B to C will be used in drawing the position-time graph"*. It is obvious from the excerpt that, those pre-service physics teachers had little understanding of the concepts of stationary objects. Their challenges do not rely on the distance covered by an object but on failing to include the time spent by an object when at rest.

Finding Distance in Positive and Negative Directions

Findings revealed that pre-service physics teachers had difficulties in calculating the total distance travelled for position-time graphs when positive and negative directions are involved. Figure 4 below represent an example of a question where pre-service teachers were asked to calculate the total distance travelled by an object from time = 0 Hours to time = 20 Hours.

Figure 4

An example of an item for calculating distance in opposite directions

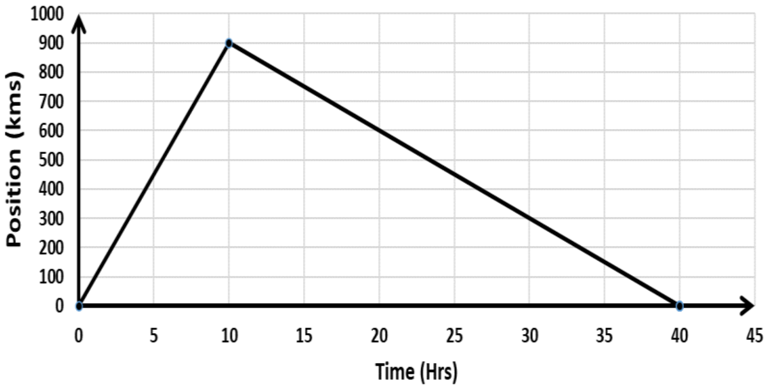


Figure 4 represent question number 19 where pre-service physics teachers were required to calculate the total distance covered by adding the distance in the positive direction (900 km) and the distance in the negative direction (300 km). After adding the two distances were expected to get 1200Kms as the correct answer. Nevertheless, many pre-service teachers got 600 km because were subtracting distance in the negative direction from distance in the positive direction. Pre-service teachers getting 600 km instead of 1200 km, signifies their difficulties in interpreting the distance covered in the positive and negative directions. Pre-service teachers need to know that the total distance is calculated by adding different distances covered in position-time graphs without regarding their directions.

Also, in question 15, the distractor B was more popular than the correct answer D because learners subtracted forward direction of 20 m from backward direction of 60m and got 40m. The correct answer D which few participants got 80m is obtained by adding forward and backward directions the two distances.

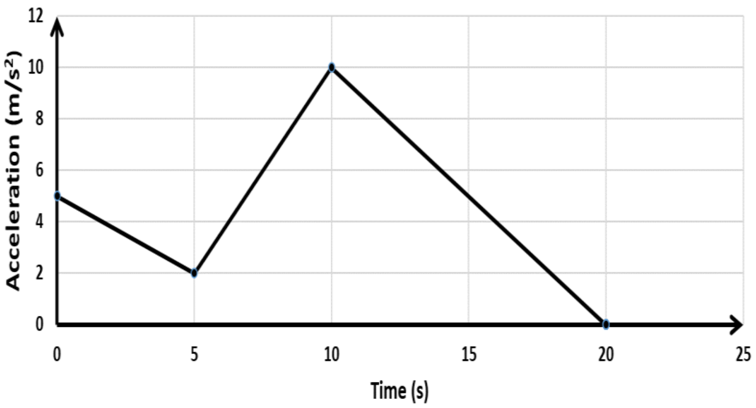
Findings from pre-service physics teachers' interviews complemented findings from the test. For example, when pre-service teachers were asked to explain how can they calculate the total distance for objects moving forward and backward directions in position-time graphs, the response of pre-service teacher T8 from Teachers' College X was *"the total distance is calculated by subtracting the total distance covered in the negative direction from the distance covered in the positive direction and vice-versa. It depends on the numerical value, the direction with a higher numerical value will subtract the direction with a lower numerical value"*. This passage above entails pre-service teachers' misconceptions they had concerning the movement in the opposite directions. The point to note is that going somewhere and coming back to where you were before does not mean that you have not covered any distance but means twice the distance has been covered.

Interpreting Area Under Kinematics Graphs

The findings have revealed that pre-service physics teachers had challenges interpreting areas under acceleration-time graphs. They tend to confuse between area under the acceleration-time graph with the area under the velocity-time graph. Figure 5 is an example of a test item for testing the ability of pre-service teachers to interpret the area under the acceleration-time graph.

Figure 5

An example of an item testing area under acceleration-time graph



In Figure 5 above, pre-service physics teachers were required to use the relationship which exists between acceleration, velocity and time ($Acceleration = \frac{\Delta Velocity}{time}$) to get the meaning of area under the acceleration-time graph. Since the area under the acceleration-time graph is the product of acceleration and time, the resulting product is the change in velocity. However, the majority of pre-service physics teachers associated the area under the acceleration-time graph with the total distance covered under the graph. Many pre-service teachers opted for the total distance covered under the graph which is related to the area under the velocity-time graph but not the acceleration-time graph. This shows the challenges pre-service physics teachers had with kinematics graphs areas.

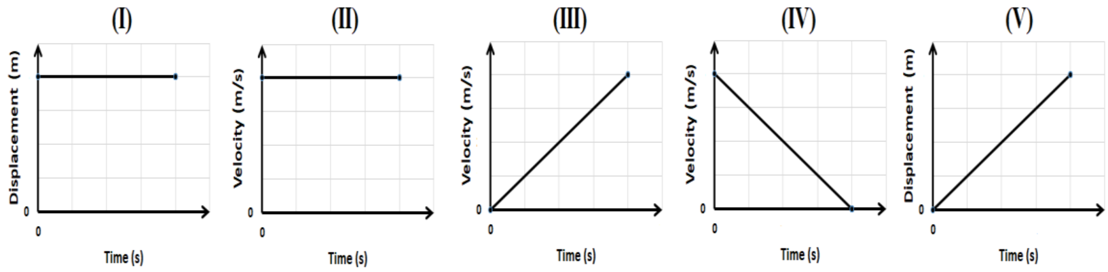
Interviews from pre-service teachers revealed similar findings to that of the test. For example, Pre-service teacher T15 from Teachers' College Y, when asked the meaning of area under the acceleration-time graph, T15 contended that *"the area under acceleration-time graphs is equal to the total distance covered under the graph"*. This excerpt indicates confusion between areas under-acceleration-time graph with that under the velocity-time graph. It seems pre-service physics teachers were familiar with the area under velocity-time graphs and know little about area under acceleration-time graphs.

Converting between Kinematics Graphs

Findings revealed that pre-service teachers had misconceptions about converting from one kinematics graph to another. They had challenges of identifying whether the graph can change its shape when variables of acceleration, position and velocity interchange at a given time. Figures 6 below represent an example of a test item for testing the ability of pre-service teachers to convert between kinematics graphs. They were asked to select two graphs which represent motion with constant velocity as indicated below.

Figure 6

An example of item for testing converting between kinematics graphs



Pre-service teachers were expected to select the choice having one velocity-time graph with constant velocity (graph II) and one displacement-time graph with constant velocity (graph V). Only 18.67% of pre-service teachers were able to get the correct answer. 51.6% got it wrong because they selected the choice with displacement-time graph having an object at stationary (graph I) and the velocity-time graph with constant velocity (graph II). The findings indicate that they were confused between stationary object in the position-time graph with constant velocity in the velocity-time graph because the two graphs look similar.

Similarly in question number 23 where students were required to convert position to velocity-time graphs. The popular destructor was A while correct options was D. Examination of distractor A more closely is that, physical structure of the its figure resembles to the structure of the figure in from the questions. Learners could not notice the change in the shapes of graphs when variables of position-time graph were interchanged with variables of velocity-time graph. Generally, pre-service teachers had difficulties in converting between kinematics graphs.

Discussions

This section expands on the results by thoughtfully addressing them in relation to the pertinent literature. Engaging pre-service physics teachers from teachers' training colleges to answer kinematics graphs conceptual questions has no doubt that, it revealed several challenges facing them. Pre-service teachers' difficulties with slope by reading directly the axis coordinates for the lines which do not start from the origin and assigning them values to slope were reported by Beichner (1994) who found that students were directly reading coordinate values from the axis and assigning them to the slope. This worked well in finding the slope of the line passing through the origin but fail when the line does not pass through zero. However, Amin et al. (2020), Antwi (2015), McDermott et al. (1987), Núñez et al. (2022), & Phage et al. (2017) showed that many students were unable to associate the slope with velocity and acceleration.

Inadequate skills in locating the object at stationary were reported by McDermott et al. (1987) who asserted that, when college students were asked to draw the position-time graph of a stationary object, some draw only a line starting from the origin rather than a horizontal line. Also, Alimisis &

Boulougaris (2014) reported that when students were given position-time graphs with forward and stationarydirections, their interpretation was good. However, when they were given a question which required them to draw the position-time graph with forwarding and stationary positions, it was hard to locate the stationary position. Moreover, Amin et al. (2020) stated that students often make mistakes when plotting graphs of rest objects. The mistake occurs because learners demonstrate the movements observed directly without noticing the time axis.

The challenge of calculating total distance in opposite direction aligns with Alimisis and Boulougaris (2014) who said it was difficult for students to find the total distance for a person walking at constant speed straight from a certain point to the wall and coming back to that point. In addition, findings align with McDermott et al. (1987) who argued by giving an example that, students were unable to translate forward and backwards from the position-time graphs.

As this study reports the confusion between area under velocity time graphs and acceleration-time graphs, the report by Antwi (2015), Antwi et al. (2018), Beichner, (1994), McDermott et al. (1987), & Phage et al. (2017) also have reported difficulties in interpreting areas under kinematics graphs. However, these reports indicate that students are failing to interpret areas under kinematics graphs because they do not understand different areas under graphs, including curved areas.

The revealed findings about students' difficulties in converting between kinematics graphs aligns with previously findings. Beichner (1994) revealed some confusion among learners when could not notice the change in the shapes of graphs when variables of position-time graph, velocity-time graph, and acceleration-time graph were interchanged. Moreover, Antwi (2015), Antwi et al. (2018) & McDermott et al. (1987) reported that students had difficulties converting between position, velocity, and acceleration time graphs. Generally, it is very important for physics educators in Tanzania to address these challenges accordingly when teaching kinematics graphs to students.

Conclusions and Implications

The challenges revealed in this study include difficulty in interpreting slope of the line graph which does not start from the origin, presenting the stationary position of the object on the graph, and difficulty in calculating total distance when forward and backward directions are involved. Other challenges include difficulty interpreting the area under acceleration time graphs and difficulty converting from one graph to another. The challenges identified require teachers to find proper learner-centred teaching and learning methods that will address those challenges and raise the performance of students on kinematics graphs and physics in general. Based on these findings and the conclusion made, the study recommends that physics teachers themselves need to know the challenges when teaching kinematics graphs to students.

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Appendix

Kinematics Graphs Concept Inventory

THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY
PHYSICS EXAMINATION FOR PRE-SERVICE TEACHERS
KINEMATICS GRAPHS QUESTIONS
TEACHERS' COLLEGE____________

INSTRUCTIONS

1. Choose the correct choices for all 25 multiple choice questions
2. All answers must be written in the box provided for each question
3. Each question carries four marks (4%)

Time 90 minutes (1.5 hours)

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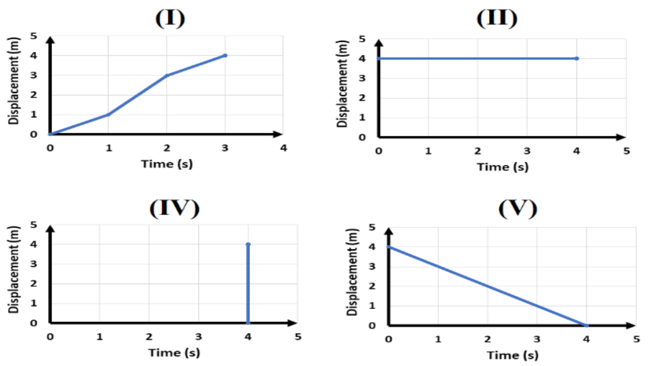
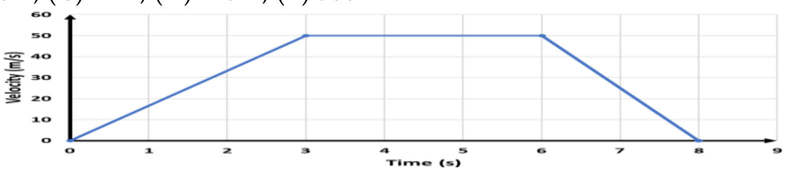
1. The displacement versus time graph for five objects is given below. Which object is moving fast in the forward direction with constant velocity?
(A) II, (B) III, (C) I, (D) V, (E) IV

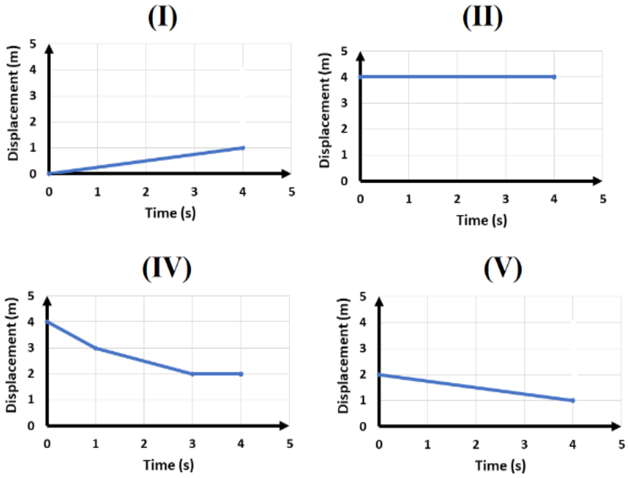


2. An object starts from rest and then moves as shown in the area of the figure below. The total distance travelled by the object is
(A) 550m, (B) 400m, (C) 24m, (D) 275m, (E) 300m

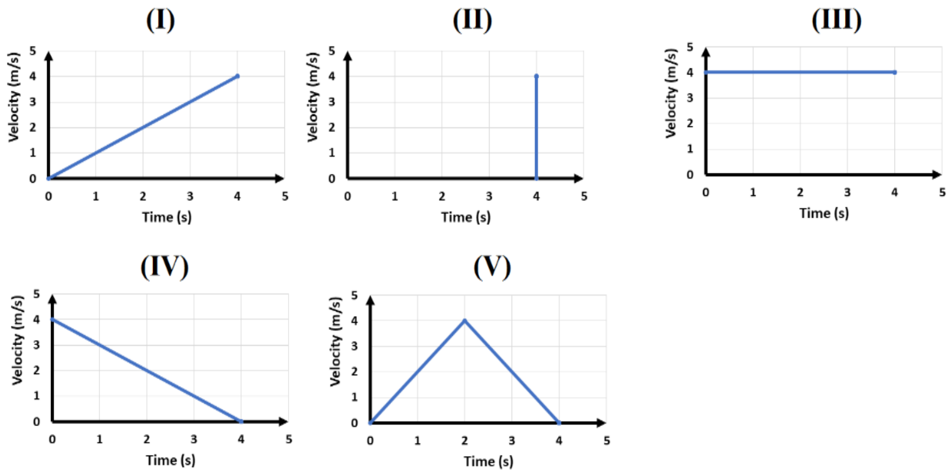


3. Here is the position-time graph of the motion of the object. Which of the following indicates that the object is not moving at all?
(A) BC and DE, (B) AB and EF, (C) CD and FG,
(D) BC and CD, (E) EF and FG

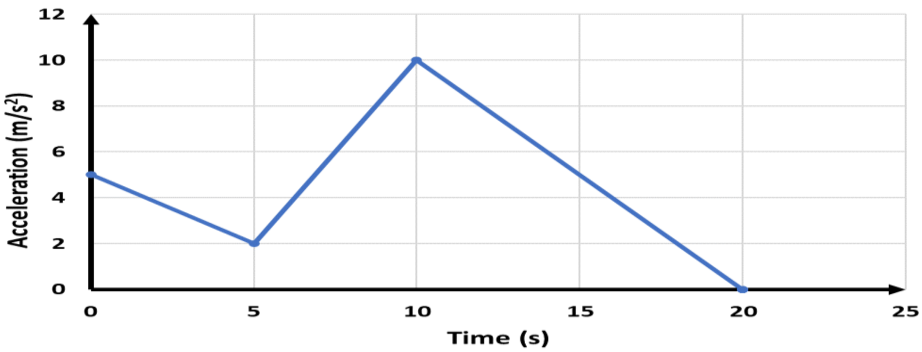
4. The displacement versus time graph for five objects is given below. Which object is moving slowly in the backwards direction with constant velocity?
(A) I, (B) II, (C) IV, (D) III, (E) V



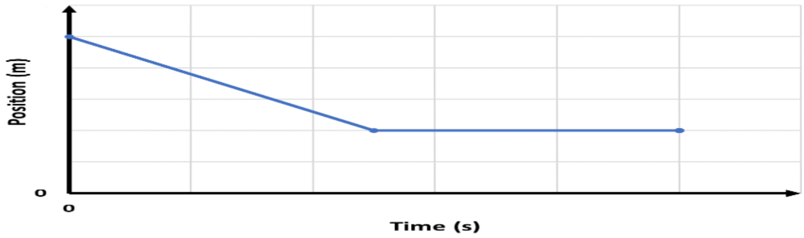
5. Given five velocity-time graphs below. Which graph represents an object's motion at constant velocity?
(A) IV, (B) V, (C) II, (D) III, (E) I



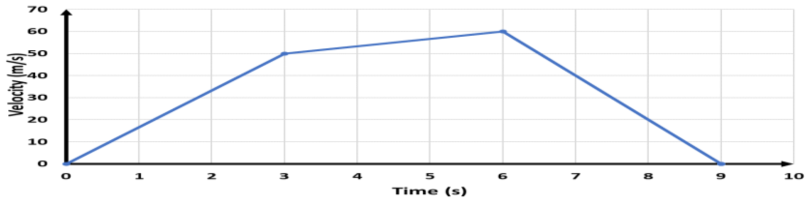
6. An acceleration-time graph is shown in the figure below. What does the area under the graph represent?
(A) Change in velocity (B) Total distance travelled (C) Retardation
(D) Total velocity (E) Total time spent



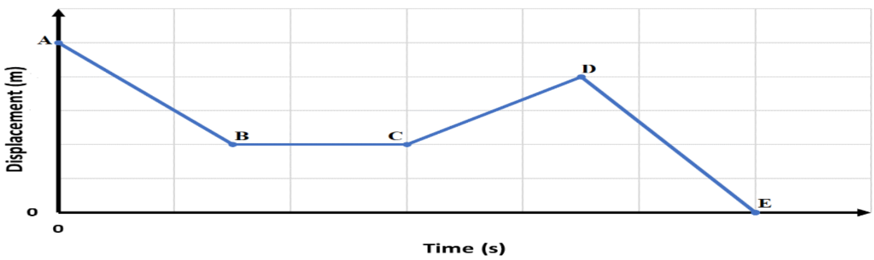
7. Two states of an object are shown in a position versus time graph below. How can you describe the states of an object?
(A) An object is moving backwards and then forward,
(B) An object is moving forward and then stopped
(C) An object is moving backwards and then stopped,
(D) An object is stopped and then moves forward
(E) An object is topped and then moves backwards



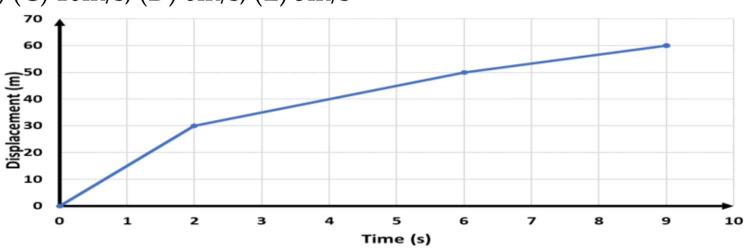
8. You are provided with a velocity-time graph below. The acceleration of an object between time (t)=6 seconds to time (t)=9 seconds is
(A) 20m/s² (B) 10m/s² (C) 50m/s² (D) -20m/s² (E) -10m/s²



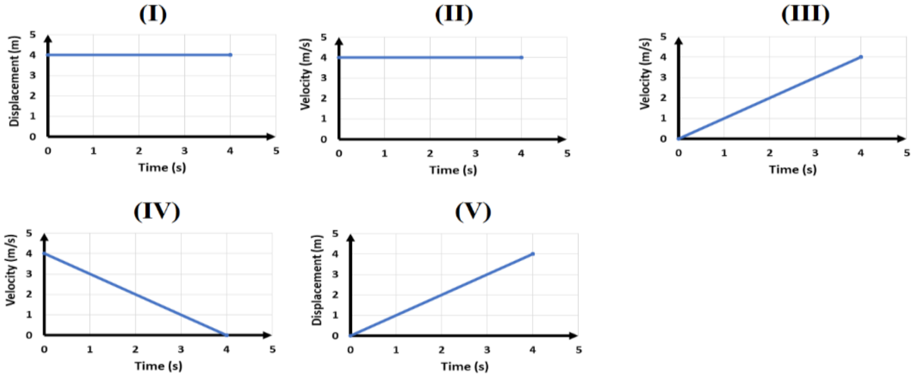
9. Different states of an object are shown in a displacement versus time graph below. How can you describe an object's motion from point A to point D?
(A) Forward, backward, and stationary,
(B) Backward, stationary, and then forward
(C) Stationary, backward and then forward
(D) Stationary, forward and then backwards
(E) Forward, stationary, and then backwards



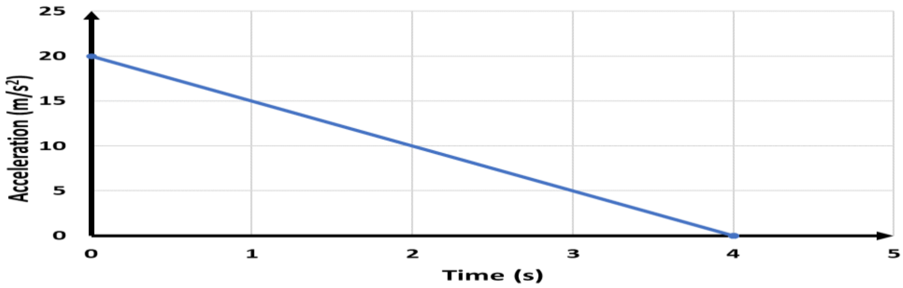
10. An object was moving as shown in the figure below. What is the velocity of an object at a time (t) = 4 seconds?
(A) 2m/s, (B) 4m/s, (C) 10m/s, (D) 6m/s, (E) 5m/s



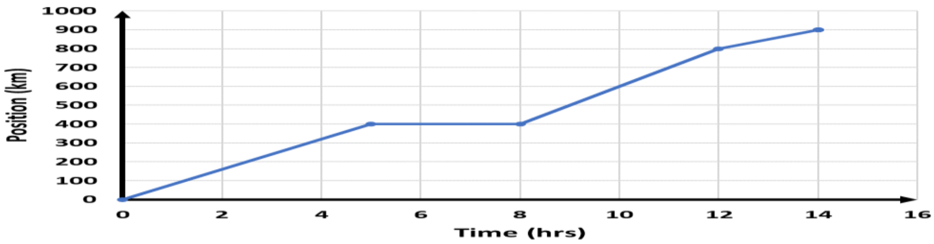
11. Given graphs below. Identify two graphs representing objects' motion at constant velocity
    (A) II and III, (B) I and II, (C) II and V, (D) III and IV, (E) IV and V



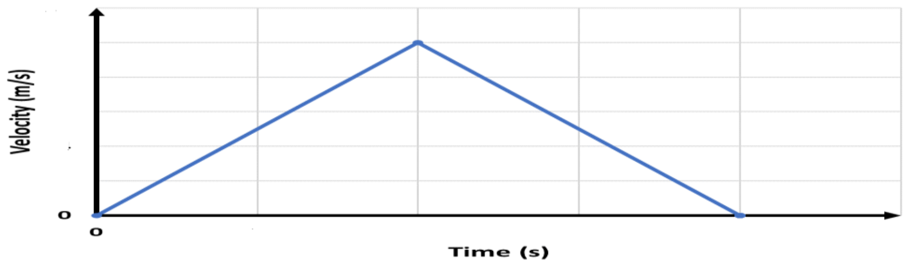
12. The figure below represents the acceleration-time graph. The change in velocity is?
    (A) 10m/s, (B) 40m, (C) 40m/s, (D) 80m/s, (E) 20m/s



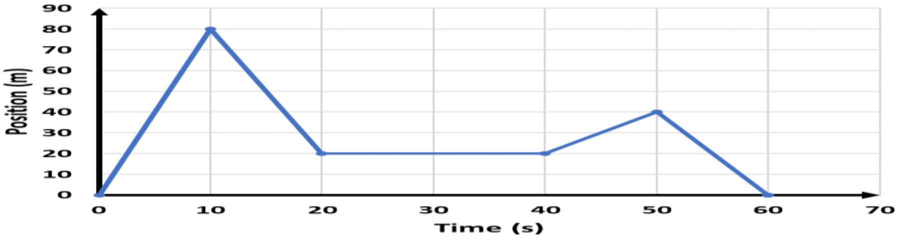
13. A car was travelling as shown in the figure below. How long does it travel from time(t) = 5 hours to time(t) = 12 hours?
    (A) 400km (B)200km (C)600km (D)1000km (E) 800km



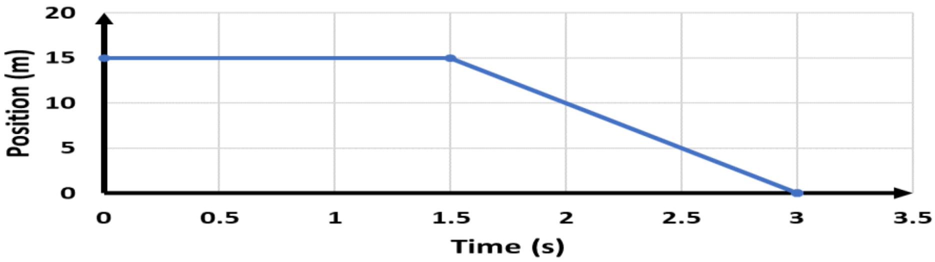
14. Given the velocity-time graph below. Which sentence is the best interpretation of the object's motion?
    (A) Deceleration then acceleration.
    (B) Acceleration then deceleration
    (C) Retardation then acceleration
    (D) Deceleration then retardation
    (E) The object does not move.



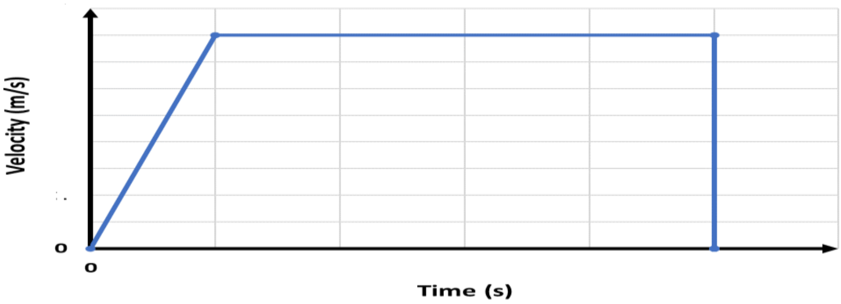
15. An object path is indicated in the displacement time graph below. How long does it journey from time (t) =10 seconds to time (t) =50 seconds?
(A) 20m, (B) 40m, (C) 60m, (D) 80m, (E)100m



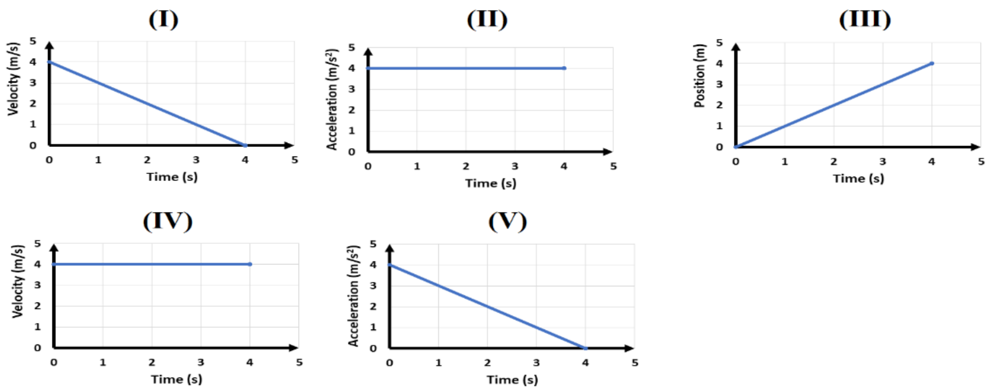
16. Displacement-time graph for an object is shown below. The velocity at the time (t) = 2 seconds is about?
(A) 5m/s, (B) 15m/s, (C) 10 m/s, (D) 2m/s, (E) 3m/s



17. You are given a graph as shown in the figure below. What does the area represent?
(A) Acceleration (B) Speed (C) Retardation
(D) Total distance travelled (E) Velocity

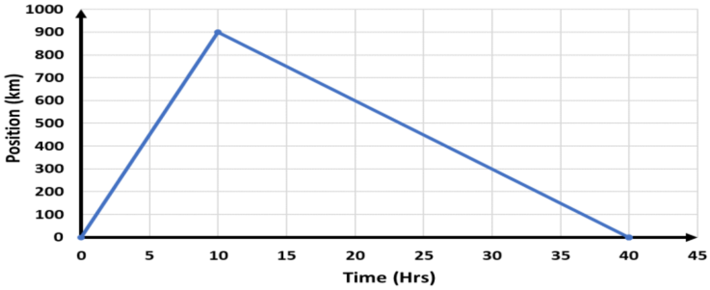


18. Consider the following graphs, noting the different axes

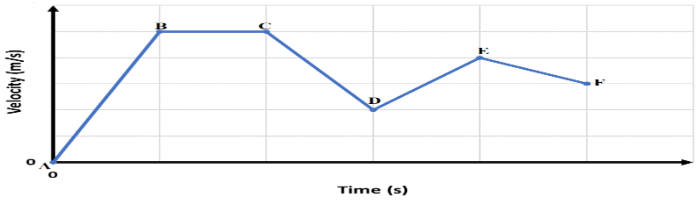


Identify graphs which indicate motion with zero acceleration
(A) I, II and IV (B) III and IV (C) II and V (D) IV only (E) V only

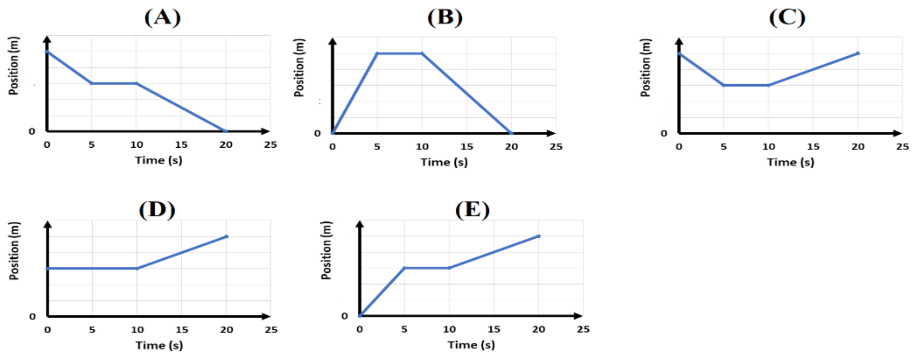
19. The following graph is a position-time graph. The distance of the object from time (t) =0 hours to time (t) = 20 hours is
(A) 900Km, (B) 600Km, (C) 1200Km, (D) 1000Km, (E) 1500Km



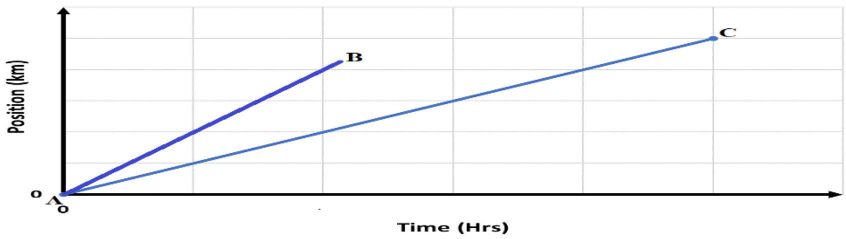
20. An object starts from rest and then moves as shown in the velocity versus time graph below. At which state an object is said to be decelerating?
(A) AB and DE, (B) AB and EF, (C) DE and EF,
(D) BC and DE, (E) CD and EF



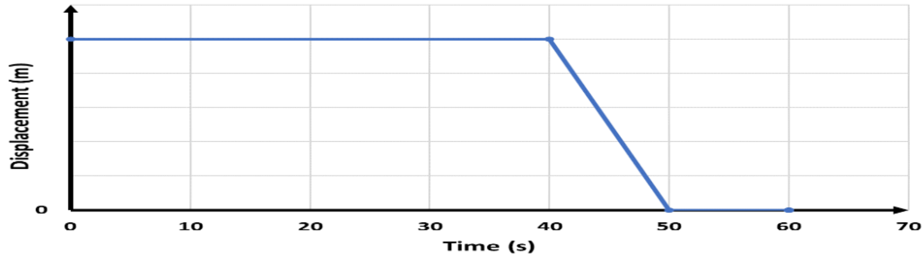
21. An object starts from rest and moves forward with constant velocity for five seconds. It then stops for five seconds and continues forward with constant velocity for 10 seconds. Which of the following graph correctly describes this situation?



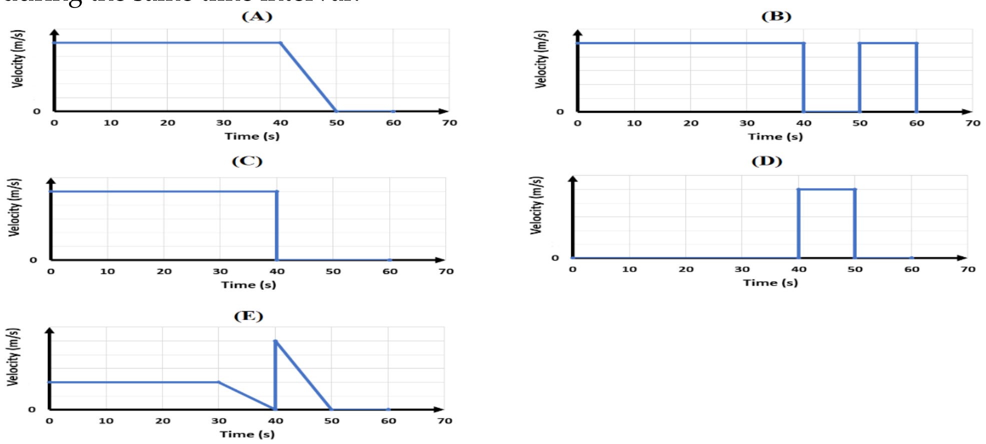
22. By referring to the slope of the distance-time graph below. Which one of the sentences best describes the motion of object AC?
(A) AC is moving slower than AB
(B) AC and AB have the same velocity
(C) AC is moving faster than AB
(D) AC is moving forward and AB backwards
(E) AC is moving backwards and AB forward



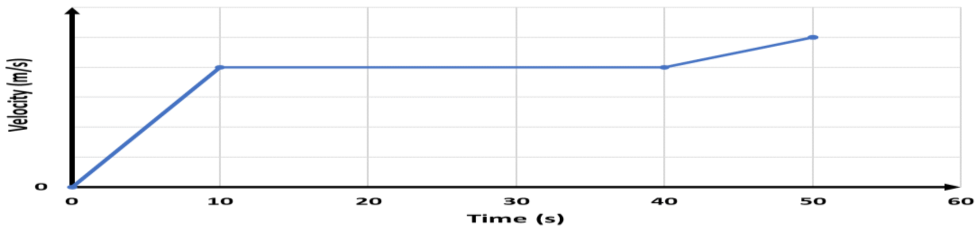
23. The displacement-time graph below represents an object moving motion during a 60s-time interval.



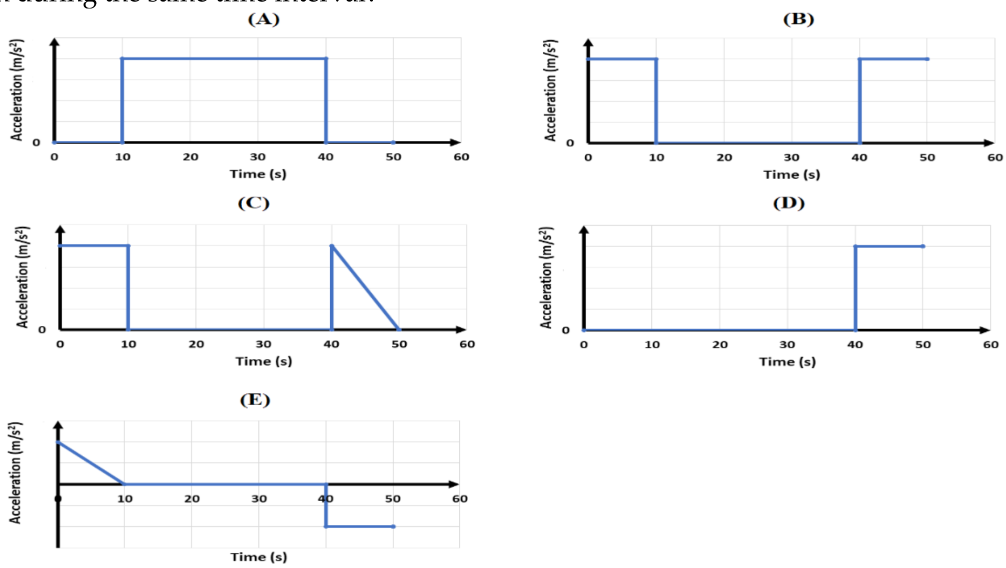
Which one of the following graphs of velocity versus time would best represent the object's motion during the same time interval?



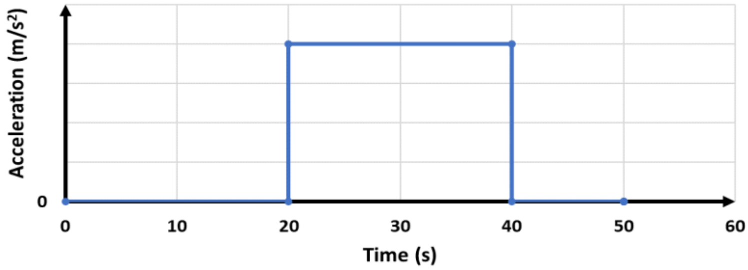
24. The velocity-time graph below represents an object's motion during a 50s-time interval



Which of the following graphs of acceleration versus time would best represent the object's motion during the same time interval?

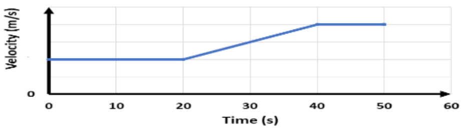


25. An acceleration graph for an object during a 50s-time interval is represented below

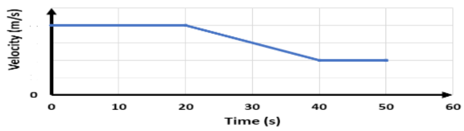


Which of the following velocity versus time represents the object's motion during the same time interval?

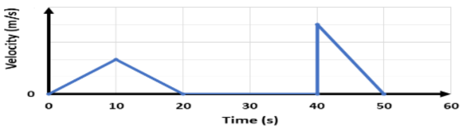
(A)



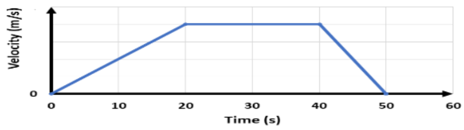
(B)



(C)



(D)



(E)