Evaluating Teachers' Understanding of Kinematical Concepts in the NSF Summer Institute for Inservice Teachers

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The Physics Education Group

- Evaluate Teaching Methods and Instruction
- Identify Student Difficulties
- Develop Curriculum
  - *Physics by Inquiry*
    L.C. McDermott and the Physics Education Group
    (John Wiley & Sons, Inc., New York, NY, 1996)
  - *Tutorials in Introductory Physics*
    L.C. McDermott, P.S. Shaffer, and the Physics Education Group
    (Prentice Hall, Upper Saddle River, NJ, 2002)
- Instruct
  - Courses
  - Workshops
  - Institutes

The National Science Foundation Summer Institute for Inservice Teachers

- Duration: 6-week course
- Purpose:
  - Strengthen Understanding of Physical Concepts
  - Introduce Inquiry-Based Learning
- Curriculum: *Physics by Inquiry*
- Topics covered: Kinematics, Dynamics, and Electric Circuits
- Participants: Elementary, Middle, and High School Teachers
- Backgrounds: Varied

Previous Research

Investigation of student understanding of the concept of acceleration in one-dimension

D. E. Trowbridge and L. C. McDermott,
Am J. Phys. **49**(3), 242 (1981)

Assessment of Student Understanding

Individual Demonstration Interviews

Analysis of Course Examinations

Acceleration Comparison Task 2

Examine Quantitative Understanding of the Concept of Acceleration.

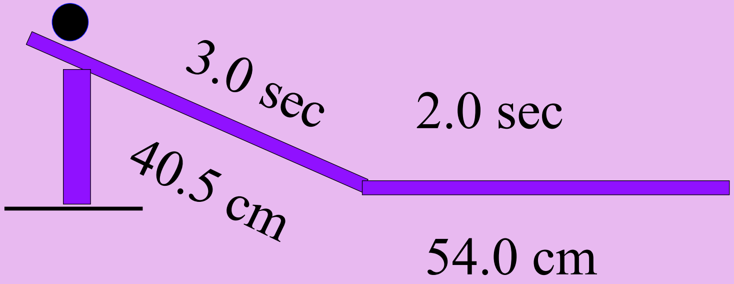
Acceleration Comparison Task 2

v_i = 0 cm/s

$v_{avg\ 2}$ = (54cm/ 2s) = 27 cm/s = v_f = 27 cm/s

a = (v_f - v_i)/ 3 s. = (27 cm/s - 0 cm/s)/ 3s = 9 cm/s^2

Ball A

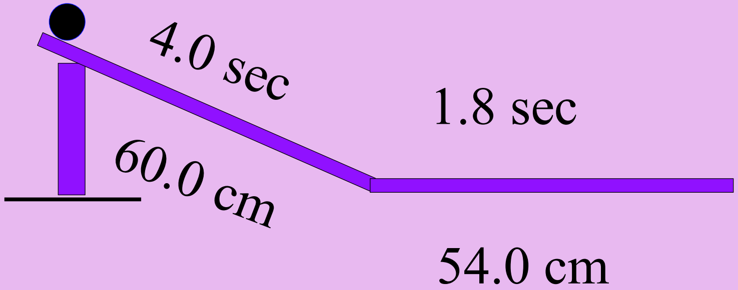


v_i = 0 cm/s

$v_{avg\ 2}$ = (54cm/ 1.8s) = 30 cm/s = v_f = 30 cm/s

a = (v_f - v_i)/ 4 s. = (30 cm/s - 0 cm/s)/ 4s = 7.5 cm/s^2

Ball B



Given the information on the diagram and that the two balls start at rest and roll down the sloping section of the tracks onto level sections where they have uniform motion, determine which ball has the greater acceleration on its sloping section.

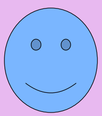
25% correct

Purpose

To evaluate whether or not teachers in the Summer Institute displayed a robust understanding of average velocity and instantaneous velocity.

Determining whether or not the teachers were capable of using their understanding of these concepts to determine acceleration after instruction.

Operational Definitions



A Good Physics Student-- a physics student who scores 900 or better on the Physics GRE.

Length-- describes or tells you how long something is.

Average Velocity--the total displacement traveled divided by the time interval it took to travel that displacement.

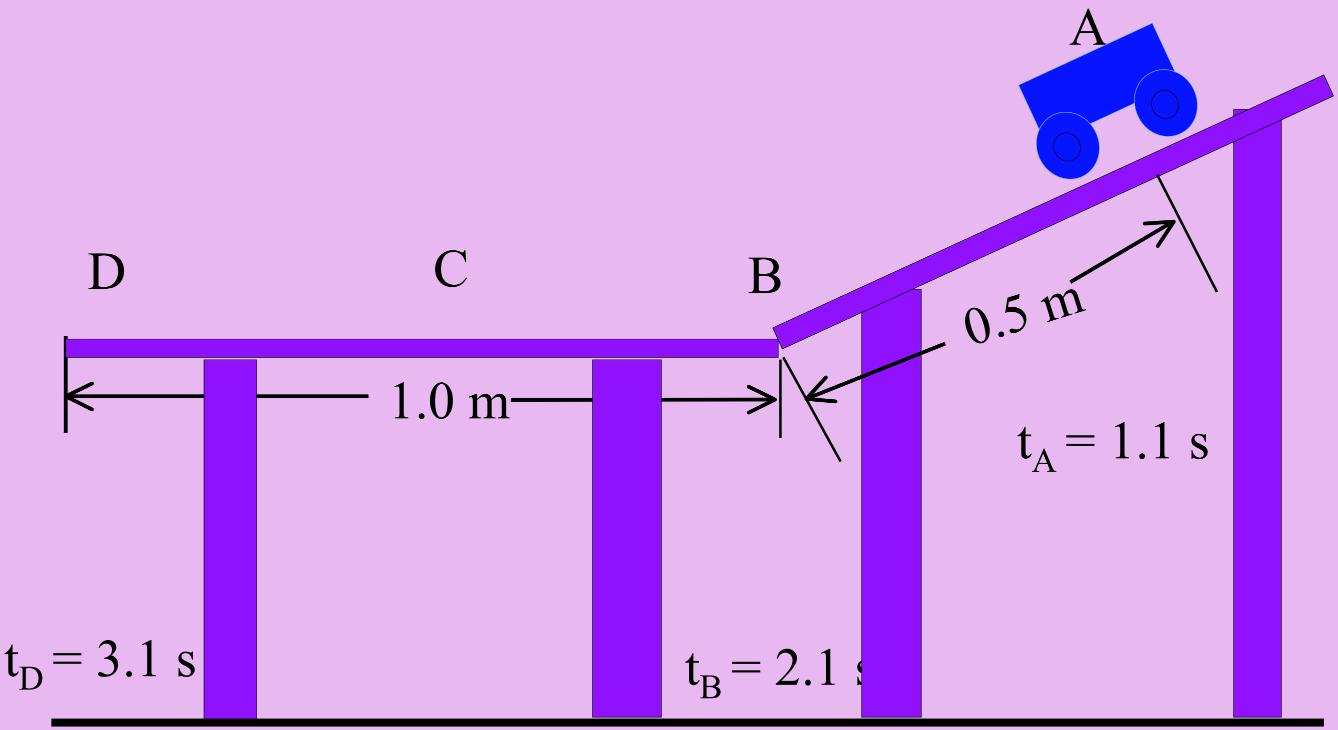
Instantaneous Velocity--The average velocity for the time interval surrounding the point of interest, when the interval is so small that the motion is nearly uniform within it.

Acceleration--The change in velocity divided by the total change in time required to change the velocity from the initial to the final.

Method

- Analyze pretests
  - Module Pretest Question 3
    - 27 students
    - prior to any instruction
  - Pretest for Section 10
    - 23 students
    - average and instantaneous velocity covered; acceleration introduced
- Analyze Examination Question 1
  - 27 students
  - average velocity, instantaneous velocity, and acceleration covered
- Analyze interviews
  - 21 students
  - kinematics sections complete; students engaged in dynamics

Module Pretest Question 3



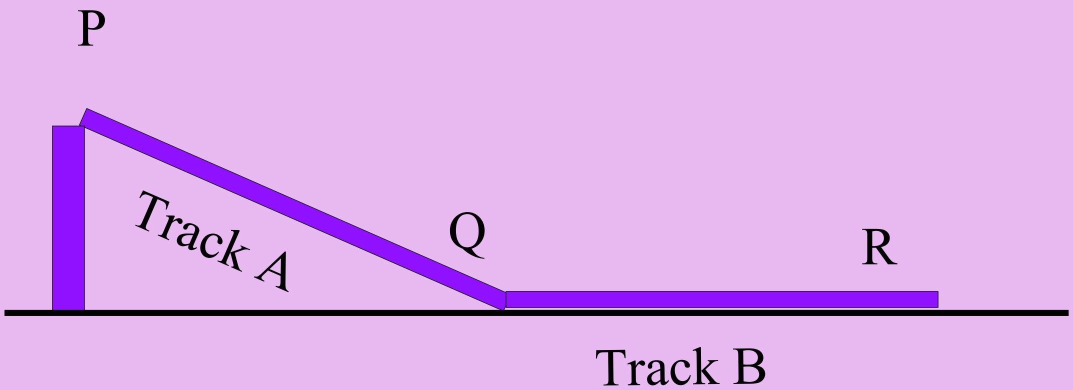
Correct

22% (6)

N = 27

The cart is released from rest, speeds up down the incline, and then moves with constant speed along the 1 meter segment of track. Determine the speeds of the cart at points A, B, C, and D.

Pretest for Section 10



correct

43% (10)

N = 23

Clock 1 is stopped at the instant that the ball is released from rest at point P

Clock 2 is stopped when the ball reaches point Q

Clock 3 is stopped when the ball reaches point R.

At the end of the experiment

clock 1 reads 1.2s

clock 2 reads 4.4 s

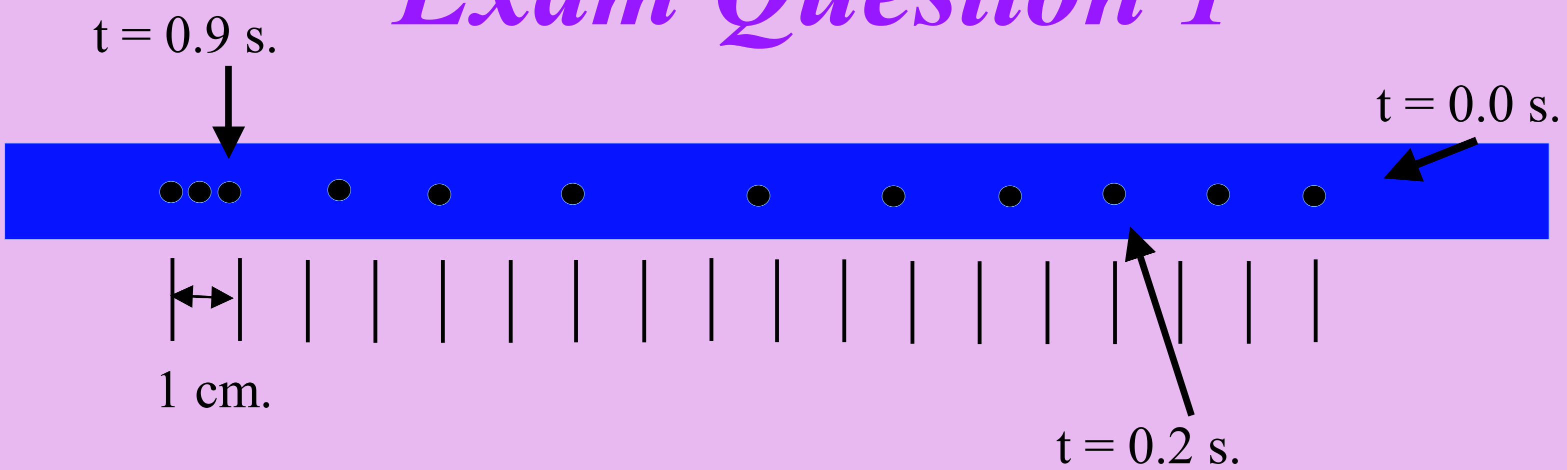
clock 3 reads 6.0 s.

correct

52% (12)

N = 23

Exam Question 1



correct

A = 89%

B = 89%

C = 100%

D = 67%

A. What was the speed of the cart at t = 0.2 s?

B. What was the speed of the cart at t = 0.9 s?

C. What is the absolute value of the average velocity of the cart over the entire interval shown on the tape?

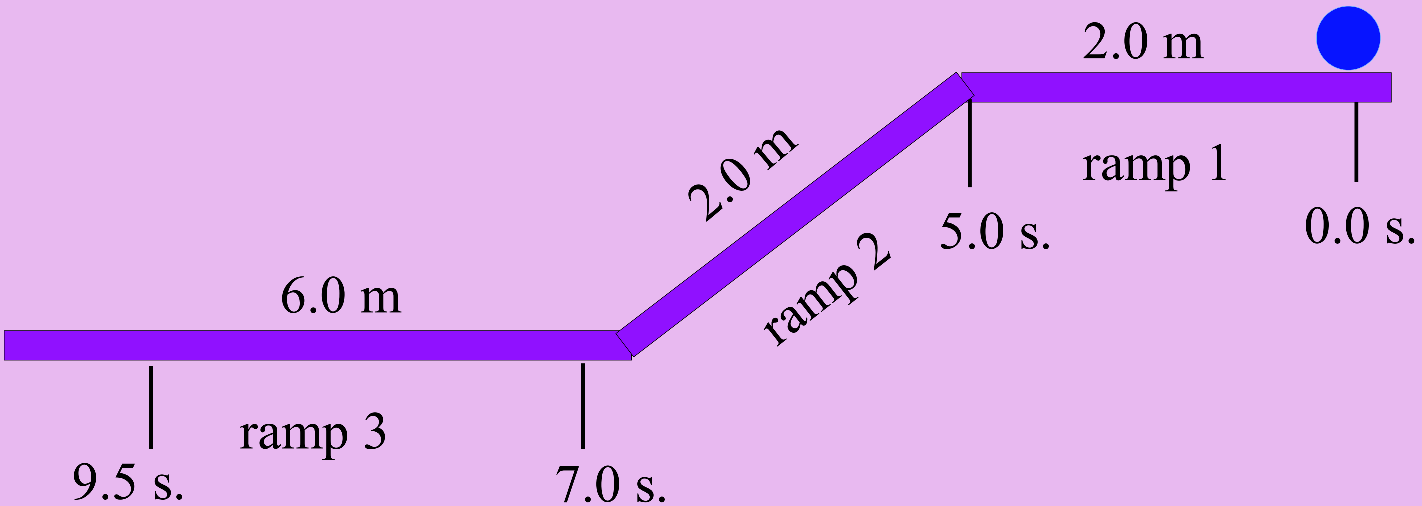
D. Give an interpretation of the number you obtained in part C.

Format of Interviews

Students were asked to:

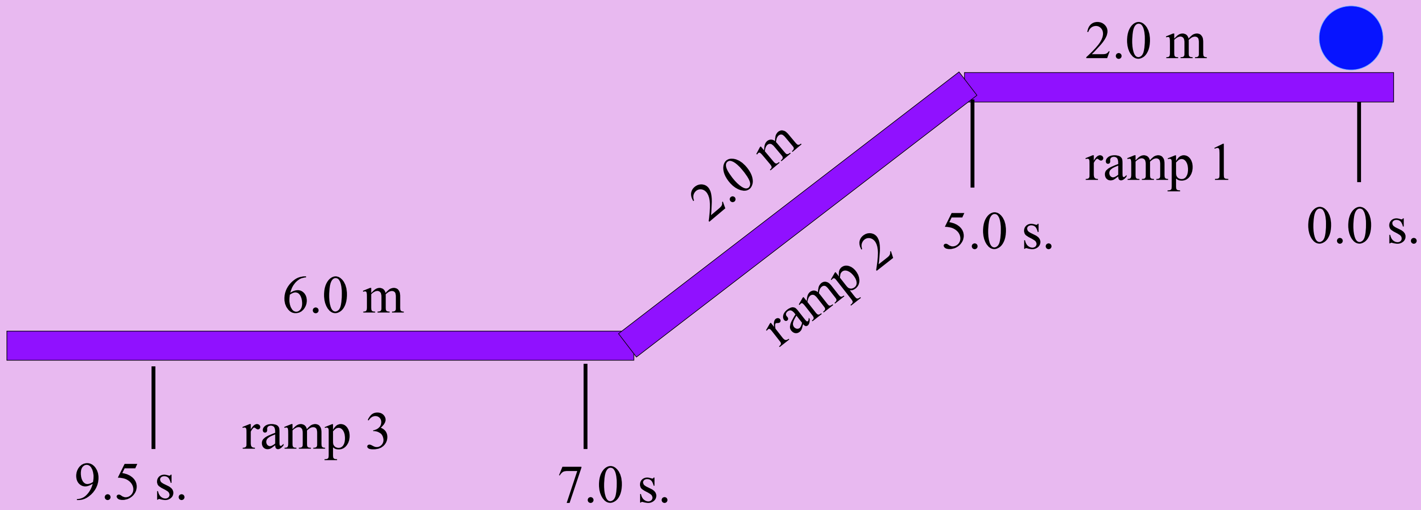
- define acceleration
- describe a valid method that could be used to determine acceleration for a scenario similar to Acceleration Comparison Task 2
- define average and instantaneous velocity
- interpret average and instantaneous velocity
- differentiate between average and instantaneous velocity
- determine which kind of velocity is referred to in their definitions of acceleration

Interview Question 1



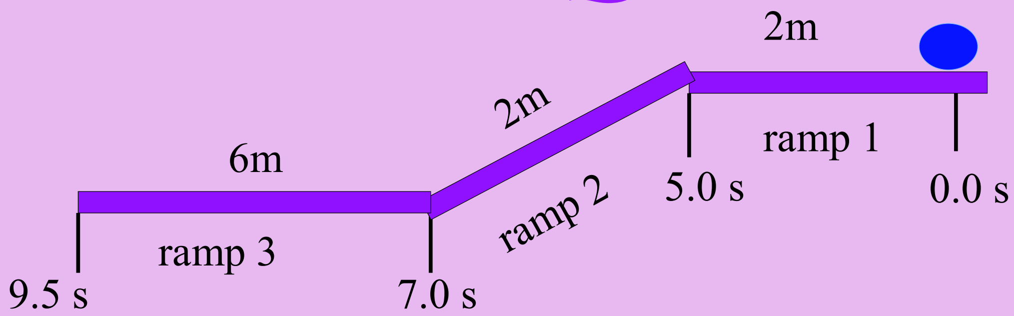
Results for Interview Question 1

81% of the teachers answered correctly.



And so what am I going to do with you [the length of ramp 2]? You've got 3 m. covered in 3 s. . . . .The change in time was 3 s. and you know that you went 3 m. Does that matter? . . . It's your final velocity minus your initial velocity. And we already know that.

Interesting Responses to Interview Question 1



It's going to be change in distance. It's going to be 3 meters. Change in time; it's going to be 3 seconds. So, that's going to give us basically a meter per second. That's going to be velocity. I want to say it's going to be 1 meter per second per second.

. . . it was in constant motion prior to that [entering ramp 2] you weren't seeing any acceleration. . . . So, it has a starting velocity of zero at that point in terms of the acceleration. So, it's going to be 0 meters per second. 3 meters per second minus 0 meters per second over a 3 second time frame . . . .That [the acceleration] would be 1 meter per second per second.

Average Velocity and Instantaneous Velocity Results

Sample size 21 teachers

- 100% differentiated between average and instantaneous velocity.
- 100% interpreted instantaneous velocity the same way.
- 81% explained how to calculate instantaneous velocity.
- 91% interpreted average velocity.
- 76% explained how to calculate average velocity.

Incorrect Methods for Calculating Average Velocity

Method 1. Obviously there is the definition of average, which is . . . the beginning plus the end divided by two.

Method 2. I guess what you could do is add up all the velocities an divide them just like you would do an average . . .

Defining Acceleration

15 answered correctly

7 of those answering correctly provided explanations

6 answered incorrectly

2 of those initially answering incorrectly, resolved this after reviewing the method they used to solve Interview Question 1

Summary

- The teachers' understanding of the individual concepts increased.
- The number of teachers able to use the concepts to determine acceleration given the motion of real objects increased.
- A small percentage of the teachers were unable to articulate their understanding of these concepts.
- A small percentage of the teachers had difficulties understanding the concepts.

Module Pretest Question 3

22% (6) N = 27

Question from Pretest for Section 10

52% (10) N = 23

Question 1 A from the Mid-term Exam

89% (24) N = 27

Question 1 B from the Mid-term Exam

89% (24) N = 27

Interview Question 1

81% (17) N = 21

Conclusion

- Teachers may need to spend more time on kinematics in order to gain a more in-depth understanding of the concepts.
- Teachers may need to cover the entire curriculum rather than an abbreviated or condensed version.
- Comparison to a larger sample size would help to better clarify results.
- More thorough interviews would also help to uncover or shed light on difficulties.

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