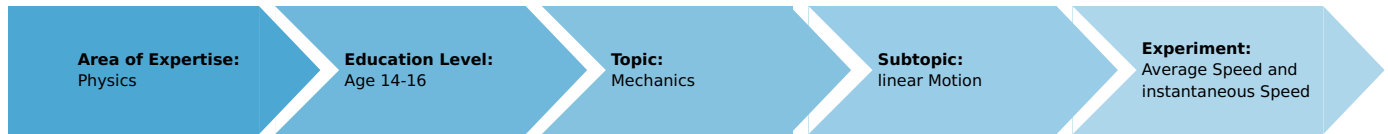


Average Speed and instantaneous Speed (Item No.: P6200200)

Curricular Relevance



Difficulty



Easy

Preparation Time



10 Minutes

Execution Time



10 Minutes

Recommended Group Size



2 Students

Additional Requirements:

- Tablet PC with DigiCart App

Experiment Variations:

Keywords:

Velocity, Kinematics, Inclined plane

Information for teachers

Introduction



Overview of experimental setup.

Educational objective

In this experiment the students learn something about the physical significance of velocity. They also learn about the concept of instantaneous velocity and can compare it with average velocity.

Task

Record a position-time diagram via the app. Select a reference point and have the average velocities calculated for a different number of averaged points. Compare the calculated values with the instantaneous velocity.

Prior knowledge

This experiment requires the concept of average velocity.

Principle

Velocity is one of the basic concepts of kinetics. It indicates how fast an object moves in space and is measured in meters per second.

The concept of instantaneous velocity is based on average velocity. If Δx denotes the change of position in a period of time

Δt , you can use

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

to calculate the average velocity \bar{v} . If now the time interval Δt is made smaller and smaller, it goes over to the infinitesimal object dt and the quotient of the above formula becomes the time derivative of the location. This is the definition of the instantaneous velocity at a time t :

$$v(t) = \frac{dx}{dt} = \dot{x}(t).$$

While two points in time are necessary for the determination of the average velocity (start and end of interval), the instantaneous velocity can be determined from the specification of only one point in time as a derivation of the position function.

Equipment

Position No.	Material	Order No.	Quantity
1	DigiCart white		1
2	1.2 m track		1
3	Height adjustable holder		1
4	DigiCartAPP		1

Safety information

For this experiment, the general instructions for safe experimentation in science teaching apply.

Introduction

Application and task

Application

Everything in the world is on the move. It is therefore worthwhile to consider the concept of velocity.

In this experiment you will learn something about the physical meaning of velocity. You will also get to know the concept of instantaneous velocity and can compare it with average velocity.

Task

Record a position-time diagram via the app. Select a reference point and calculate average velocities for a different number of average points. Compare the calculated values with the instantaneous velocity.

Equipment

Position No.	Material	Order No.	Quantity
1	DigiCart white		1
2	1.2 m track		1
3	Height adjustable holder		1
4	DigiCartAPP		1

Set-up and procedure

Set-up



Figure 1: Overview of experimental setup.

- Bring the track into a horizontal position. Now raise one end of the lane by about 10 cm using the height-adjustable holder. The track is now inclined so that the DigiCart can roll down.
- Start the DigiCart App.
- Select experiment 2 from the overview. The measurement window opens.
- Connect the DigiCart to the app (see Figure 2). Two steps are required. First, press the ON switch on the DigiCart for at least 3 seconds. Then open the connection window in the app via the bluetooth symbol (1.). The DigiCart should now be displayed there. If not, you can update the list by clicking on scan (2.). Now, one taps the DigiCart from the list once and establishes the connection via the connect button (3.). You can now hide the window again by pressing the close button (4.).

Momentan und Durchschnittsgeschwindigkeit

P6200200

Momentangeschwindigkeit:

v= m/s

Gemittelte Punkte	Δx (m)	Δt (s)	Mittlere v(m/s)

4. Schließen
2. Scan

3. Verbinden

- 11 + + ×

Figure 2: Connecting to the DigiCart.

Procedure

- Figure 3 shows the steps for the measurement process.
- The DigiCart is positioned and held in the elevated area of the track.
- Start the measurement by clicking on start measurement (1.).
- Let the DigiCart roll down the track.
- Stop the measurement by clicking on stop measurement (2.) as soon as the DigiCart has arrived at the bottom.
- By clicking on select reference point (3.), select a point in time in the position-time diagram at which the instantaneous velocity is calculated. The selection is made by sweeping the interval with the finger.

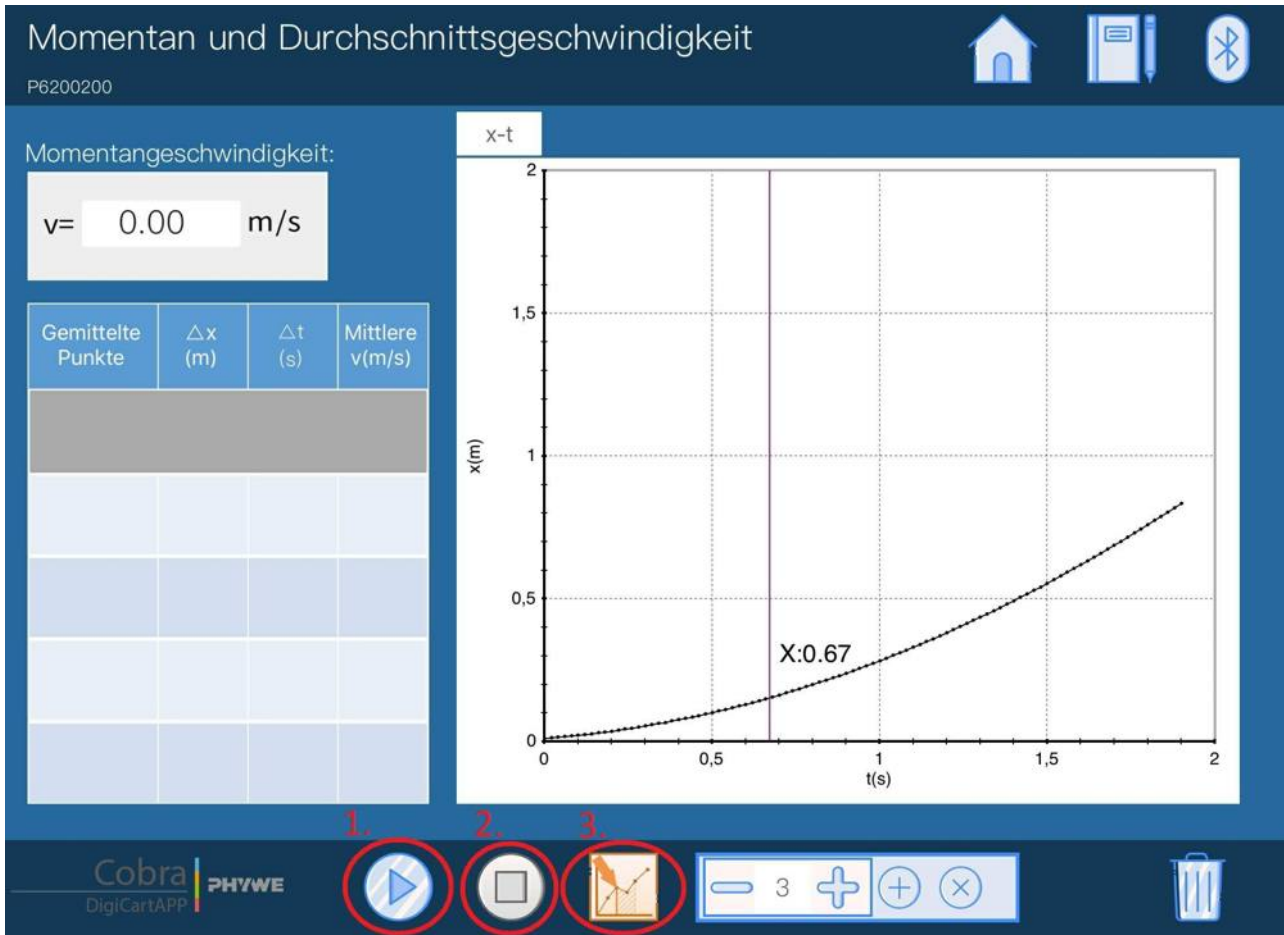


Figure 3: Measurement procedure.

Evaluation

- Figure 4 shows the steps for the evaluation.
- Use the "+" and "-" buttons (1.) and select the smallest possible value 3. The displayed number 3 indicates the number of measuring points over which the mean value is to be determined. By tapping on the add button (2.) the value is calculated and written into the left table.
- Proceed in the same way as in the last step for averaging over 5, 7, 9 and 11 measuring points.
- By tapping on a line in the table, it can be deleted using the remove button (3.) and then rewritten.
- The instantaneous velocity is automatically calculated and displayed for the selected reference point (4.).
- If the measurement is to be repeated for a new reference point, you can tap the "x-t" tab above the position time diagram (5.). The above steps can then be repeated.

The table shows that the more averaging points were used, the greater the increase in the average speed. Furthermore, the average value at the lowest number of averaging points is closest to the instantaneous speed.

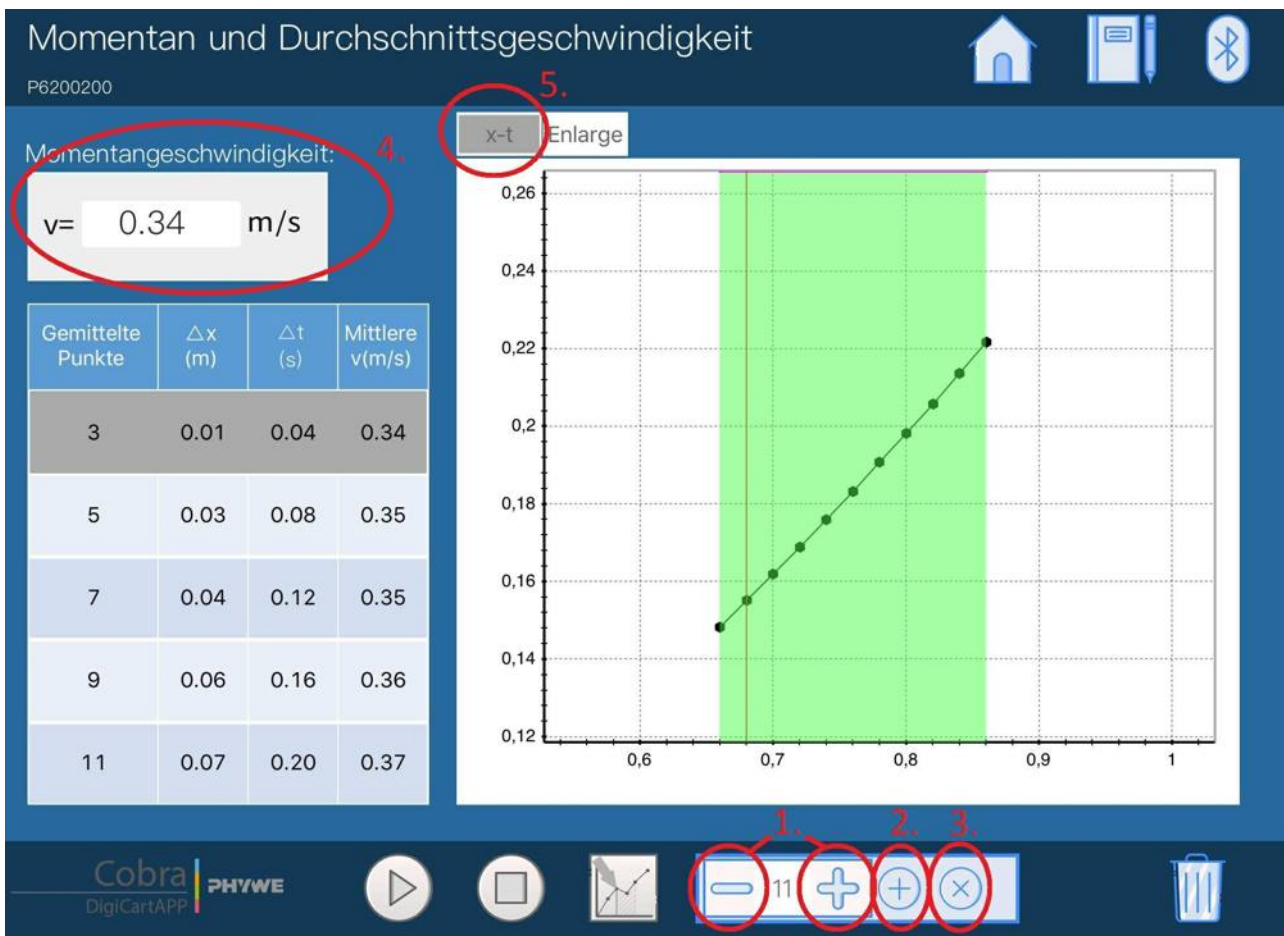


Figure 4: Evaluation procedure.

Average Speed and instantaneous Speed

Results - Evaluation 1 (1 point)

Name the main difference between the instantaneous and average speed.

Score is granted based on the occurrence of the following keywords:

- The instantaneous velocity is the velocity that a body takes at a certain point in time. For the average velocity you need two points in time, start and end.

Scoring Mode: Automatic Scoring with Keywords on Finding ONE

Results - Evaluation 2 (1 point)

What effect does it have if you use more and more points for averaging?

Score is granted based on the occurrence of the following keywords:

- Details of the movement are lost because it does not take into account what happens between the start and end times. Only the values at the beginning and end count.

Scoring Mode: Automatic Scoring with Keywords on Finding ONE

Results - Evaluation 3 (1 point)

For which motion do instantaneous and average speed match?

Score is granted based on the occurrence of the following keywords:

- For motion at constant speed.

Scoring Mode: Automatic Scoring with Keywords on Finding ONE