Kinetic energy of doing Work by constant Force

(Item No.: P6200600)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 14-16	Mechanics	Energy, Work and Power	Kinetic energy of doing Work by constant Force

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Difficult	10 Minutes	30 Minutes	2 Students

Additional Requirements:

- Tablet PC with DigiCart App

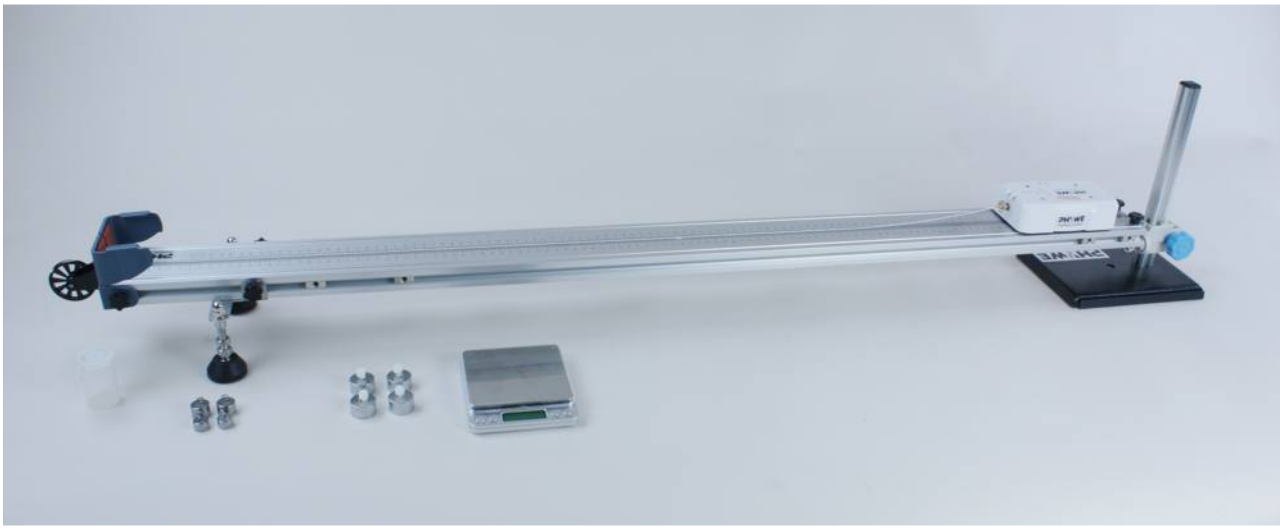
Experiment Variations:

Keywords:

Work, kinetic energy, energy conversion

Information for teachers

Introduction



Overview experimental setup.

Educational objective
In this experiment the students learn something about the physical concept of mechanical work. They will also see how work can be transformed into other forms of energy, such as kinetic energy.

Task
Record force-time, velocity-time and path-time diagrams for different forces with constant mass of the DigiCart via the DigiCart App. Compare the mechanical work done with the increase in kinetic energy.

Prior knowledge
Students should be familiar with the concept of acceleration and speed.

Principle
Kinetic Energy

For the kinetic energy E_{kin} of a body of mass m and velocity v the following equation applies

$$E_{\mathrm{kin}} = \frac{1}{2} \cdot m \cdot v^2 .$$

If the body accelerates from the velocity v_1 to the velocity v_2, the energy increase is as follows

$$\Delta E_{\mathrm{kin},1 \to 2} = E_{\mathrm{kin},2} - E_{\mathrm{kin},1} .$$

Work

If the force F acts on a body on a distance s, the work W carried out on it is calculated as follows

$$W = F \cdot s .$$

Work is energy that is transferred to a body by forces. It is important that the force acts along the travelled path.

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
5	Weight 20g		2
6	Weight 10g		2
7	Weight 50g		4
8	Plastic screw		4
9	Photo box with cord		1
10	Brass screw for force sensor		1
11	Scale		1

Safety information

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

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Introduction

Application and task

Application

Energy conversion plays a role in many areas. In a hydropower plant, for example, potential energy is converted into kinetic energy and then into electrical energy.

In this experiment you will learn something about the physical concept of mechanical work. You will also see how work can be transformed into other forms of energy, such as kinetic energy.

Task

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Set-up and procedure

Setup

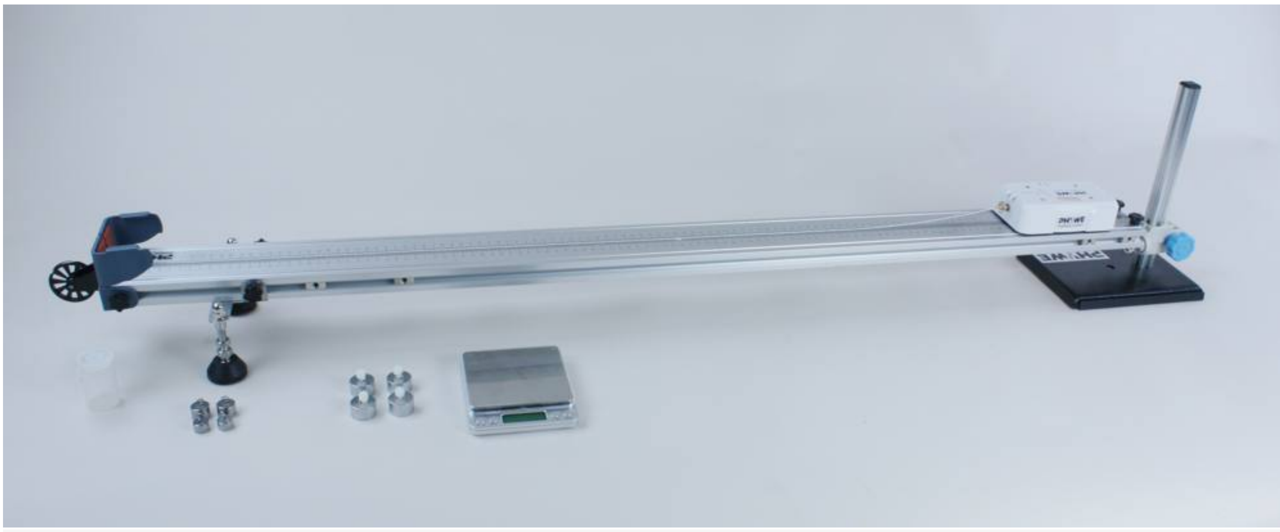

Figure 1: Overview of experimental setup.

- Use the scale to weigh the weight of the DigiCart. Make sure you also weigh the brass screw on the force sensor.
- The track must be positioned so that the impeller protrudes beyond the edge of the table. The table should be about 1 m high.
- Place the track in a horizontal position and place the DigiCart on it. Place a 10 gram weight in the film box and close it with the lid. Fasten the cord of the film can to the DigiCart force sensor using the brass screw and guide the cord over the impeller at the end of the track.
- Now place the film box on the edge of the table.
- Start the DigiCart App.
- Select experiment 6 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 chooses 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.).

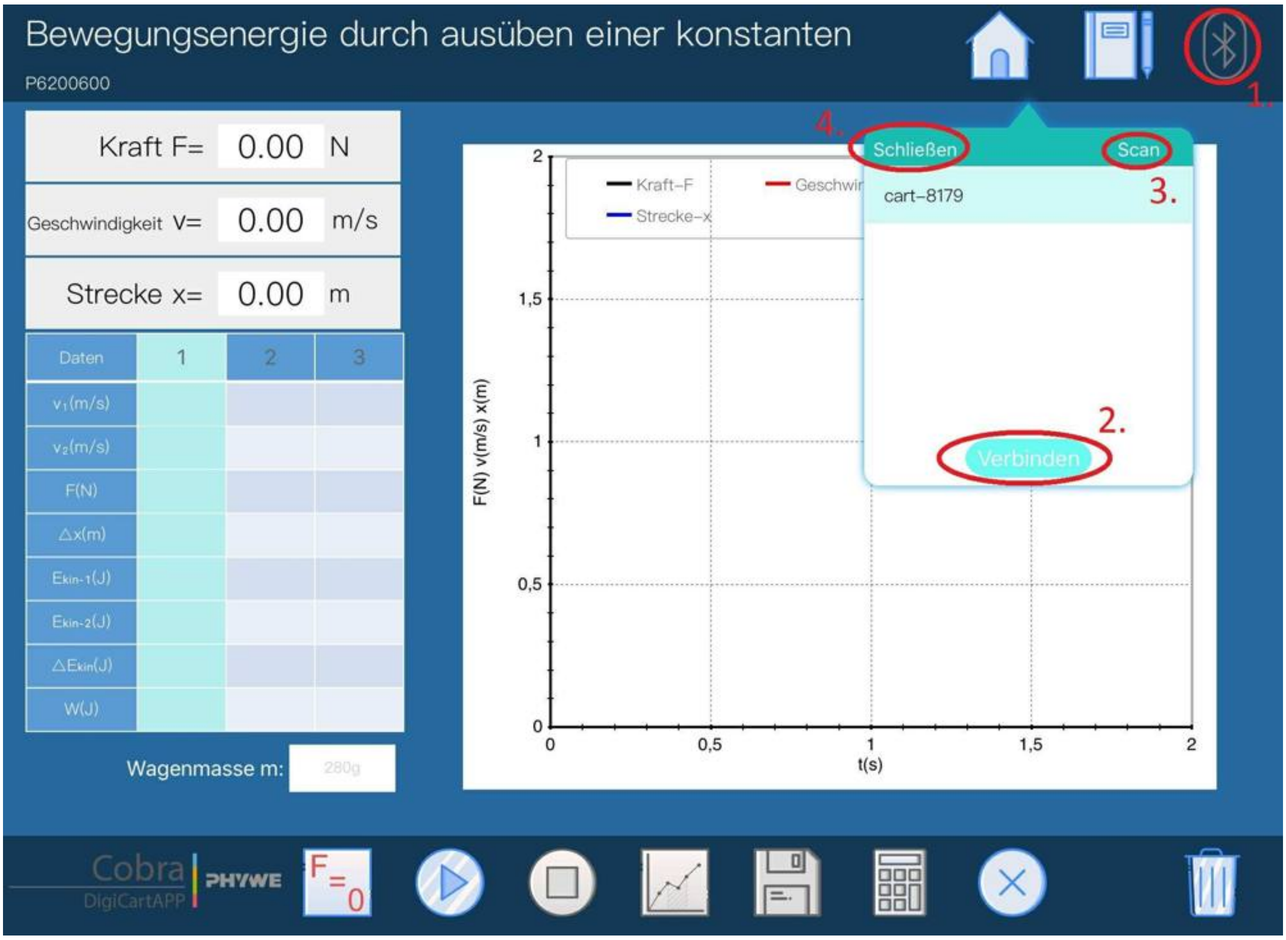

Figure 2: Connecting to the DigiCart.

Measurement

- Figure 3 shows the steps for the measurement process.
- The force, speed and position display (1.) shows the instantaneous force, speed and position.
- The force at the sensor is now set to zero via the calibration button (2.). It must be ensured that the thread is not tensioned and that no force is acting on the sensor.
- The DigiCart is placed and held at the height-adjustable end.
- The film box with the weight is removed from the table and hangs freely over the edge of the table.
- Start the measurement by clicking on start measurement (3.).
- Let go of the DigiCart. The falling weight causes the DigiCart to move.
- Stop the measurement by clicking on stop measurement (4.) as soon as the DigiCart reaches the end of the track.
- By clicking on select measuring range (5.), select a measuring range in the force-time diagram for which the mean force, distance and speed difference is to be calculated. The selection is made by swiping over the interval with your finger.
- Save the measurement by clicking the save button (6.). The values are now written to the left table.
- Increase the weight of the film box by 10 grams. Then repeat the last 7 steps.
- Then increase the weight of the film box by another 10 grams and repeat the steps again.
- To delete a column from the table, touch it and then click the delete button (7.). By a further measurement the column can be filled with new values.

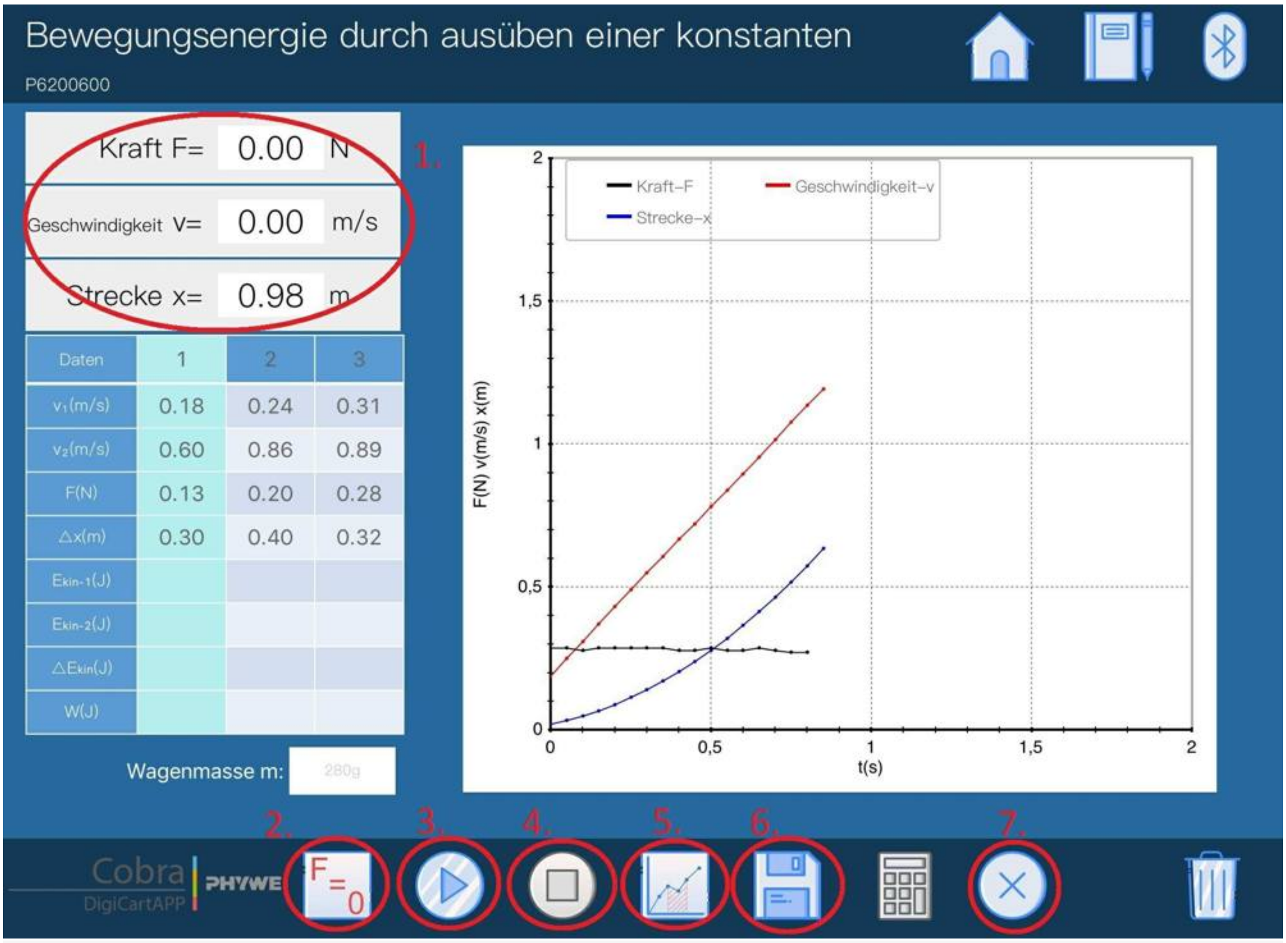

Figure 3: Measurement procedure.

Evaluation

- Figure 4 shows the steps for the evaluation.
- Enter in the field Wagenmasse (1.) the measured mass of the DigiCart in grams. The mass entered is used as the basis for further calculations. It is therefore important that all three measurement series are carried out with the same vehicle mass.
- Press the calculate button (2.) to complete the table. The kinetic energy at the beginning of the measuring range, at the end of the measuring range, the difference between the two values and the mechanical work performed are determined.

The table in Figure 4 shows that the difference between the two kinetic energies corresponds to the mechanical work performed. The work performed was completely converted into kinetic energy and thus fed to the DigiCart.

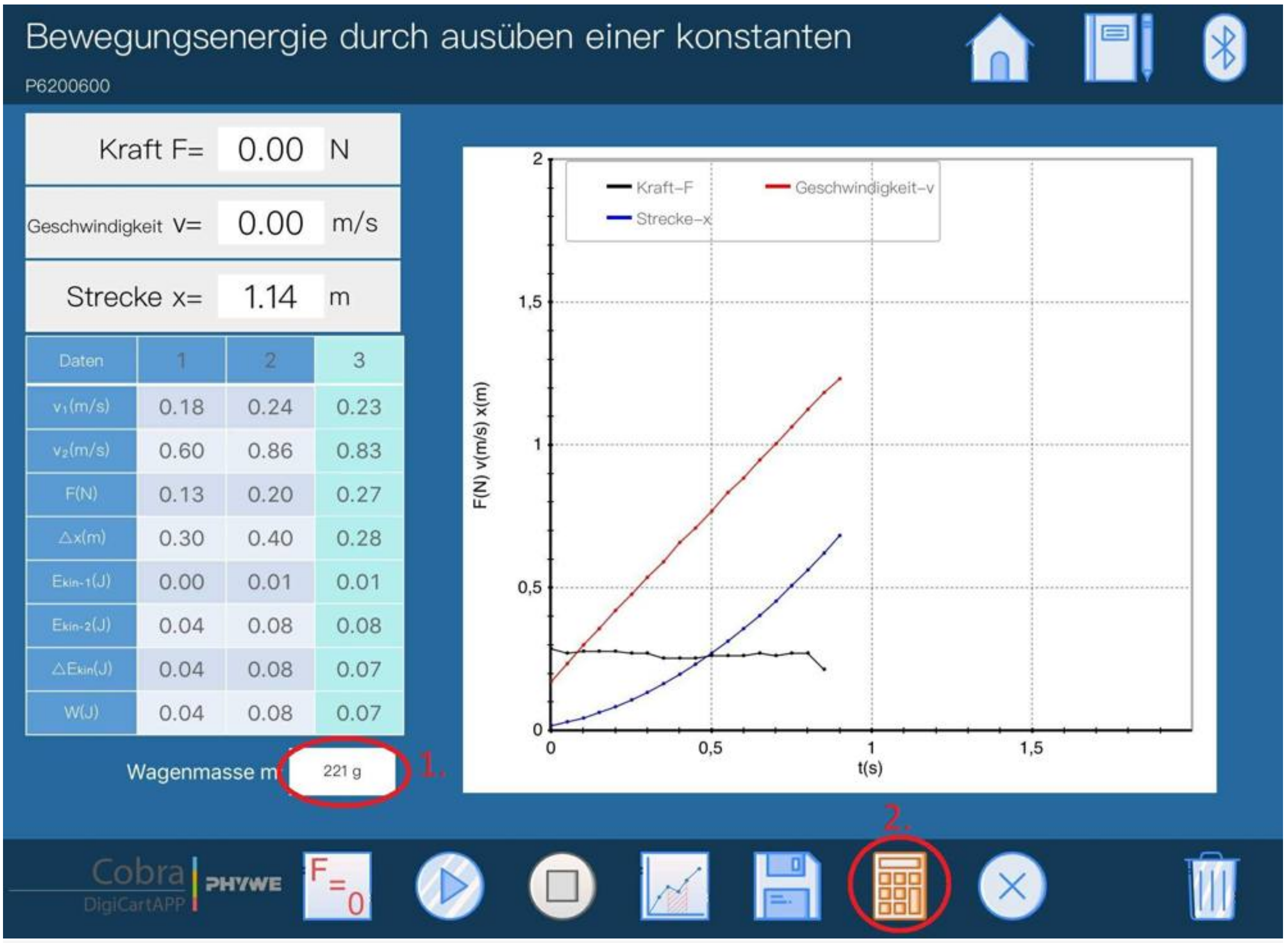

Figure 4: Evaluation procedure.

Kinetic energy of doing Work by constant Force

Results - Evaluation 1 (1 point)

How is the mechanical work calculated?

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

- W=F*s

Scoring Mode: Automatic Scoring with Keywords on Finding ONE

Results - Evaluation 2 (1 point)

Why is the car mass required for the calculation?

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

- For the determination of the kinetic energy E_kin = 0.5*m*v^2.

Scoring Mode: Automatic Scoring with Keywords on Finding ONE

Results - Evaluation 3 (1 point)

Is all mechanical work really converted into kinetic energy?

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

- No, there are friction losses. Energy is converted into heat.

Scoring Mode: Automatic Scoring with Keywords on Finding ONE

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