7.4 Laws of Linear Uniform Motion

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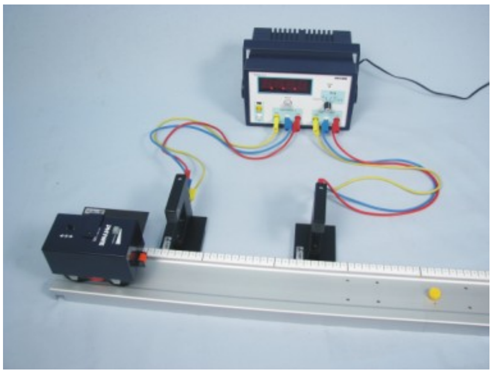
Task

Task

What laws does straight uniform motion obey?

Examine the motion of the powered measurement car at two different speed settings with the aid of the photoelectric gates and the timer.

Present the correlations in a distance-time graph and with a speed-time graph.



Use the space below for your own notes.

Logged in as a teacher you will find a button below for additional information.

Additional Informatioin

In this experiment, pupils should determine the laws of motion associated with uniform straight motion. Particularly, the presentation of the course of motion should be prepared in a distance-time graph and a speed-time graph.

Lastly, because of $a=\Delta v/\Delta t = 0$, acceleration is implied, as preparation for further experiments (see additional task).

Note

1. The measurement car with power drive, 11061.00, is needed for reproducible constant speeds.
2. The 1000 mm track is made up of 2 pieces, track 1 (11302.00) and track 2 (11303.00). In addition, track 2 has 2 bars on its underside the halves of which are inserted underneath track 1.
3. The middle seam of the gates can be used to specify their position.

Material

Material from "TESS-Mechanik ME 2" (order nr. 13272.88) and "TESS-Mechanik ME 4" (order nr. 13283.88)

Position No.	Material	Order No.	Quantity
3	Timer 2-1, incl. power supply	13607-99	1
4	Compact photoelectric gate	11207-20	2
5	Foot plate for the compact photoelectric gate	11207-22	2
6	Connecting cable, red, 32 A, 1000 mm	07363-01	2
7	Connecting cable, yellow, 32 A, 1000 mm	07363-02	2
8	Connecting cable, blue, 32 A, 1000 mm	07363-04	2
9	Track 1, l = 500 mm	11302-00	1
10	Track 2, l = 500mm	11303-00	1
Additional Material			
1	Car, motor driven	11061-00	1
2	Shutter plate for car, motor driven	11061-03	1

Material required for the experiment

Setup

Set up the track according to Fig. 1.

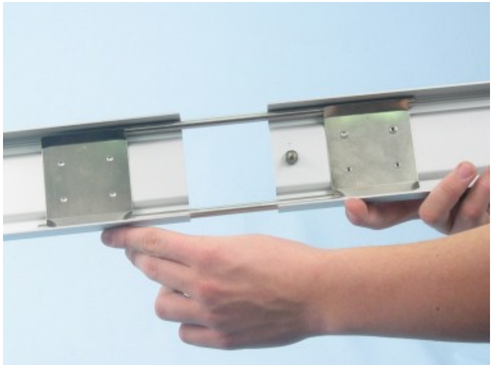


Fig. 1

Screw the foot plates onto the photoelectric gates, so that they can stand next to the track (Fig. 2) and connect the photoelectric gates to the timer (Fig. 3).

Fig. 2

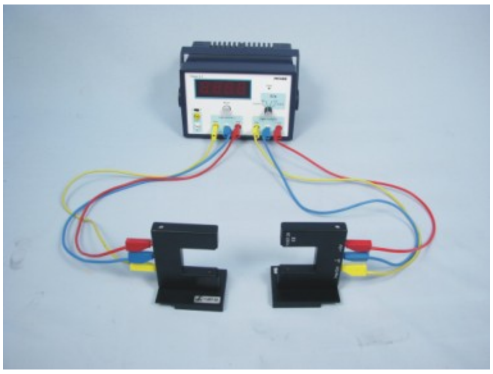


Fig. 3

On the timer, move the switch over where it says "Start" to the position to the right (⎍).

Procedure

Place the first gate 15 cm away from the beginning of the track. Place the second at a distance of s = 20 cm from the first (Fig. 4)

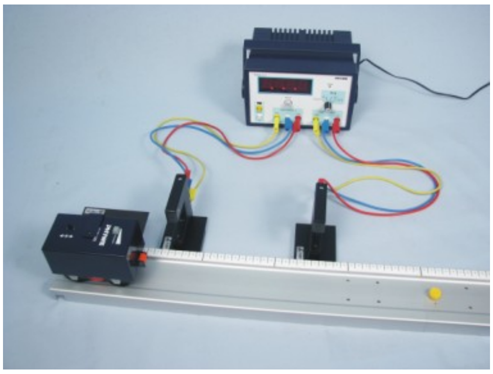


Fig. 4

Place the timer's rotary switch on the "⎍⎍" position, the third from the left. In this way, the timer shows the time between the interruption of the beams at the first gate and the second. In this experiment, this is the time which the car needs to cover the distance s between the gates.

Before each measurement, press the reset button on the timer.

Set the speed regulator on the powered car to the lowest speed (narrow end of the symbol, Fig. 5), place it, with the motor running, on the beginning of the track and record the time, t, needed by the car to cover the distance, s = 2 cm, on table 1.

Fig. 5

Move the rotary switch to the second position from the left, "⎍". Here, the timer shows the beam interruption time. This is the time during which the gate's beam is interrupted by the plate.

Let the car travel without a change in the speed setting, press the reset button bevor the car reaches the second gate and record the interruption time, Δt, which the plate with width Δs = 10 cm requires to go through the second gate (Fig. 6).

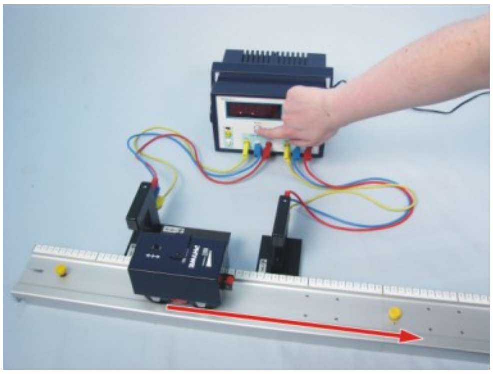


Fig. 6

Repeat the measurements for distances between the gates, *s*, of 30, 40, 50, and 60 cm.

Place the speed regulator on the powered car approximately in the middle of the symbol (middle speed, Fig. 7) and repeat the measurements. Record the results on table 2.

Round off all time measurements to two valid figures, that is, to one decimal for times greater than a second, and to two decimals for times smaller than a second.

Fig. 7

Results

Table 1

(lower speed)

s in cm	t in s	Δt in s	v_d = s / t in cm / s	v_m = Δs / Δt in cm/s
20				
30				
40				
50				
60				

Table 2

(middle speed)

s in cm	t in s	Δt in s	v_d = s / t in cm / s	v_m = Δs / Δt in cm/s
20				
30				
40				
50				
60				

Table 1

(low speed)

s in cm	t in s	Δt in s	v_d = s / t in cm / s	v_m = Δs / Δt in cm/s
20	2.4	1.2	8.3	8.3
30	3.6	1.2	8.3	8.3
40	4.9	1.2	8.2	8.3
50	5.9	1.2	8.5	8.3
60	7.1	1.2	8.5	8.3

Table 2

(middle speed)

s in cm	t in s	Δt in s	v_d = s / t in cm / s	v_m = Δs / Δt in cm/s
20	1.3	0.65	15	15
30	1.9	0.66	16	15
40	2.8	0.71	14	14
50	3.5	0.69	14	14
60	4.4	0.74	14	14

Evaluation

Question 1

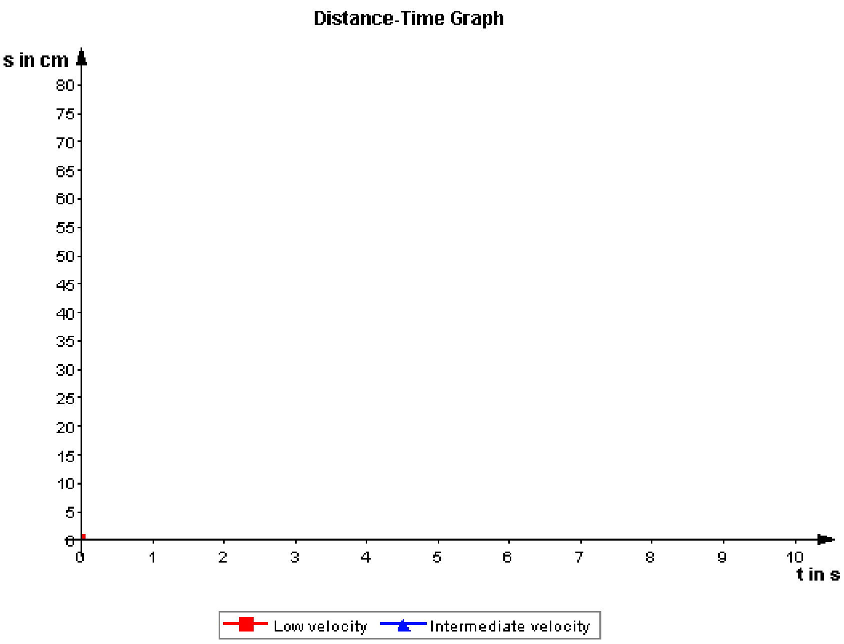
Calculate the average speed, v_d, that is, the quotient of the distance s and the time t: $v_d = s/t$. Complete the tables.

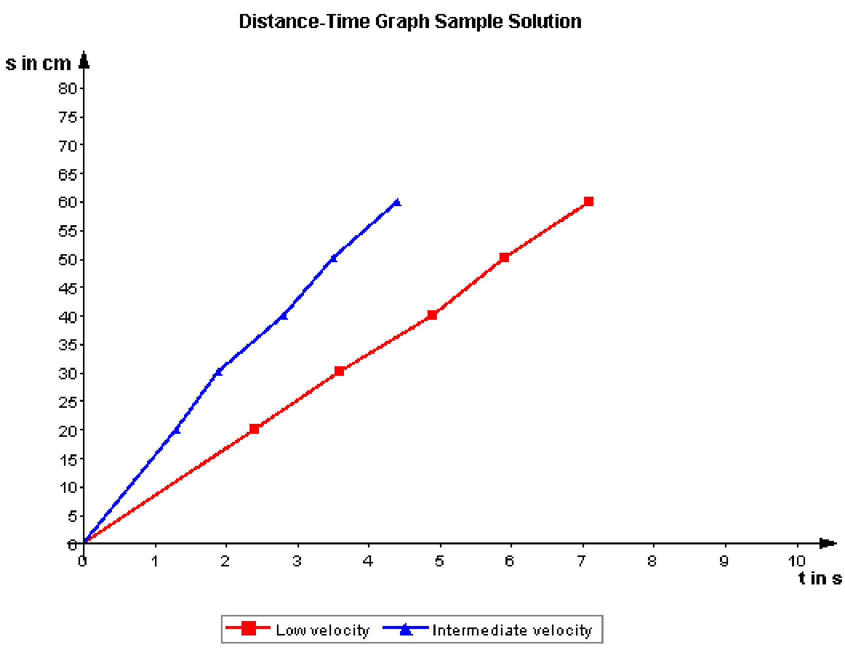
See tables 1 and 2.

Question 2

Calculate the instantaneous speed, v_m, that is, the quotient of the plate width, Δs = 10 cm and the time Δt: $v_m = \Delta s/\Delta t$. Complete the tables.

See tables 1 and 2.

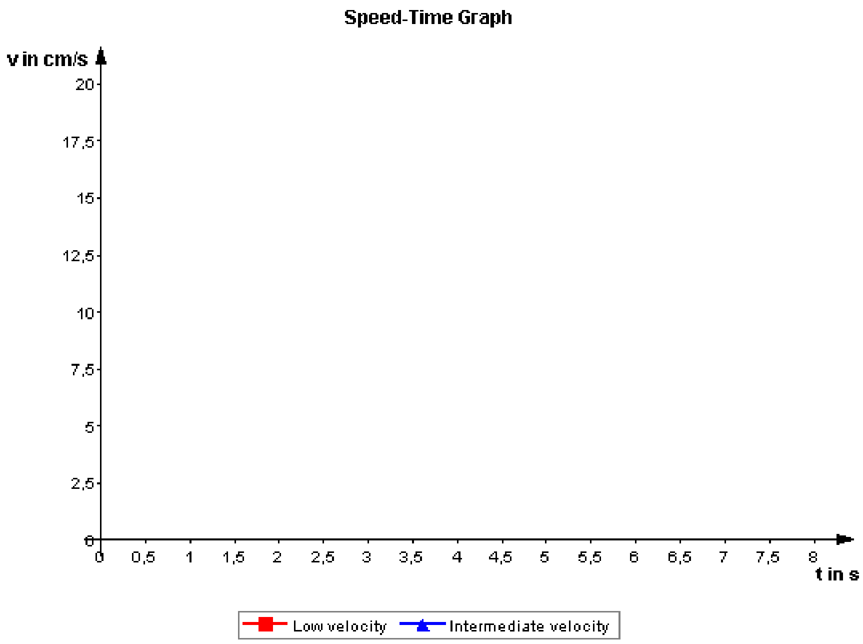

Distance-Time Graph
s in cm
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
t in s
Low velocity
Intermediate velocity

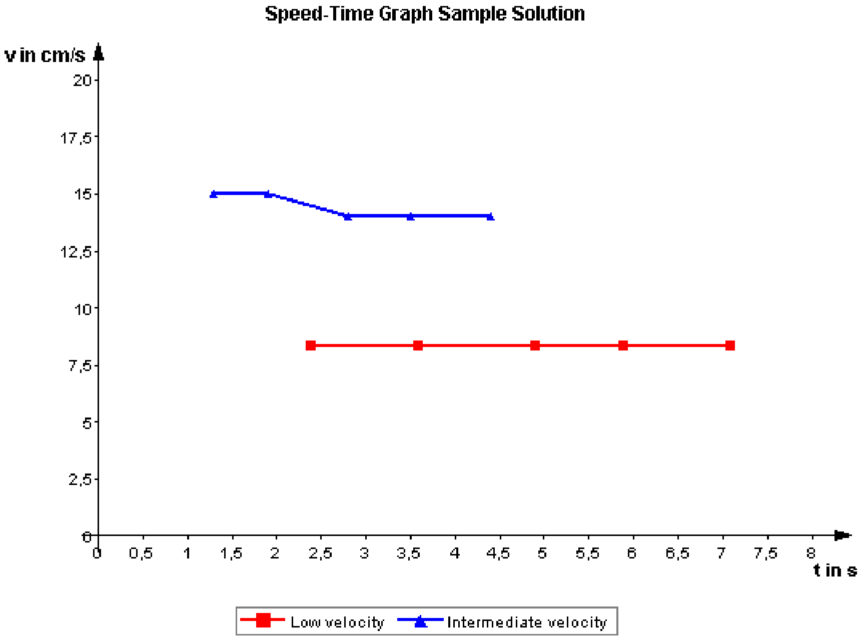

Distance-Time Graph Sample Solution
s in cm
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
t in s
Low velocity
Intermediate velocity

Question 3

The s and t values from the two tables, for the speeds v_1 and v_2 were incorporated in the distance-time graph. What curves were produced?

See the distance-time graph. Straight lines are generated, with different slopes.





Question 4

The instantaneous speeds, v_m , from both tables for both speeds were incorporated into the speed-time graph. What curves were produced?

See the speed-time graph. Straight lines are generated, the slopes of which are nil.

Question 5

From the distance-time graph, determine the speeds v_1 und v_2 and compare these with the v_d und v_m values from the tables.

The results are 8.3 cm/s for v_1 and 14.4 cm/s for v_2. These values correspond well with the v_d and with the v_m figures.

Question 6

Establish a relationship between the instantaneous speeds, v_m, and the average speeds, v_d .

The instantaneous speeds, v_m, and the average speeds, v_d, correspond very well to one another and so we can write: $v = v_d = s/t = v_m = \Delta s/\Delta t$.

Question 7

How do the curves for v_1 and v_2 run in the speed-time graph? What is the value of the slope $a = \Delta v_m/\Delta t$?

The curves for v_1 and v_2 run parallel to the time axis, their slope is zero. To put it another way: their speed is constant.

Additional Task

Question 1

Can you explain the meaning of the expression $a = \Delta v_m / \Delta t$?

The expression $a = \Delta v_m / \Delta t$ represents acceleration. Since the motion in this case is uniform, the acceleration is zero. An indication of this is the fact that the curves in the speed-time graph are parallel to the time axis.