7.7 Free Fall

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interTESS (Version 13.06 B200, Export 2000)

Task

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How does a stone fall?

Allow an electricity-conducting steel ball fall by opening a clamp with electric contacts. In doing this, the timer is started as the circuit is broken. After a certain height, *h*, has been covered in the fall, the photoelectric gate's light beam is broken by the ball, stopping the timer. The timer now shows the time, *t*, elapsed between the opening of the clamp and the interrruption of the gate's beam, i.e., the time which the ball requires to fall through the distance *h*. Change the distance, *h*, between the clamp and the gate, or in other words, the height or distance along which the ball will fall. Compare the time, *t*, needed for different distances fallen. Attempt to discover physical laws for the relation between the distance fallen, *h*, and the time needed to do so, *t*. Calculate the gravitational acceleration, *g*, from the data.

Use the space below for your own notes.

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

Additional Information

Pupils should examine a body's free fall under the earth's gravitational pull with the timer, a starting apparatus and a photoelectric gate, and they should determine the earth's gravitational acceleration from the information obtained..

Note

- A starting apparatus can also be put together with the test tube holder, 38823.00, the wire, 06092.01 (0.25 mm, 27.9 Ohm/m) and two alligator clips from 07274.03: a few tight windings of the wire as contact around both sides of the clamps on either side of the grip; the wire ends are twisted, and an alligator clip is hung from either twisted end.

Material

Material from "TESS-Mechanik ME 1" (order nr. 13271.88), "TESS-Mechanik ME 2" (order nr. 13272.88) and "TESS-Mechanik ME 4" (order nr. 13283.88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, split in 2 rods, l = 600 mm	02035-00	1
3	Bosshead	02043-00	2
4	Measuring tape, l = 2 m	09936-00	1
5	Steel-ball releasing clamp	02505-00	1
6	Steel ball, d = 19,05 mm	02502-01	1
7	Timer 2-1, incl. power supply	13607-99	1
8	Compact photoelectric gate	11207-20	1
9	Connecting cable, red, 32 A, 1000 mm	07363-01	1
10	Connecting cable, yellow, 32 A, 1000 mm	07363-02	2
11	Connecting cable, blue, 32 A, 1000 mm	07363-04	2

Material required for the experiment

Setup

Screw in the support shaft to the photoelectric gate, so it can be held in the bosshead (Fig. 1) and connect the gate to the timer (Fig. 2).

Fig. 1

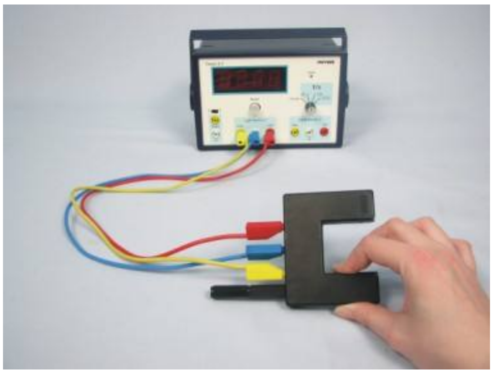

Fig. 2

Plug a yellow and a blue cable into the sockets of the respective clips. Plug the opposite ends of the cables into the "Start" panel (polarity is not important here, Fig. 3).

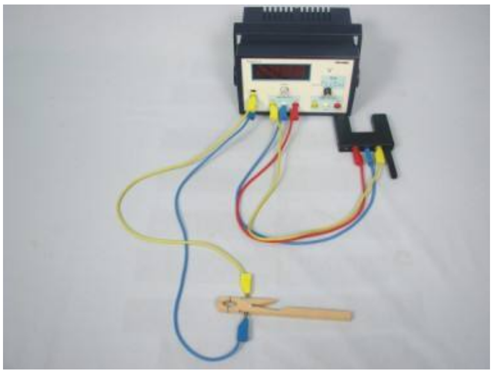

Fig. 3

Set up a support stand (Fig. 4 + Fig. 5).


Fig. 4


Fig. 5

The gate should be horizontal and placed as exactly as possible under the ball held in the clamp (Fig. 6) and the clamp should also be mounted horizontally and the ball should fall through the middle of the gate (Fig. 7).

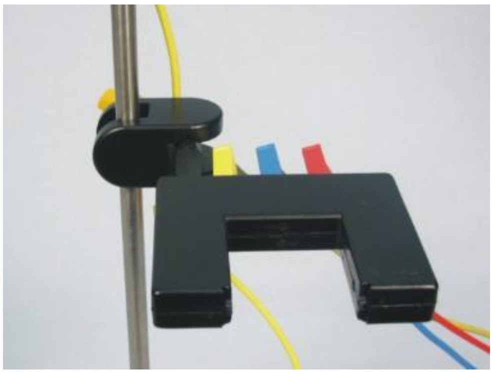
Fig. 6


Fig. 7

On the timer, place the slide switch above the panel labelled "Start", in the left position (ꜰ), so that when the circuit opens at the "Start" input of the timer, stopwatch starts.

Put the rotating switch on the "ꜰ⊓ꜰ" position, the third from the left. This way, the device shows the time between the interruption of the starting circuit and the interruption of the beam at the gate.

Procedure

Before every measurement, press the reset button on the timer **after** the ball is placed into the clamp and the starting circuit contacts are closed. The timer will start when the circuit is opened.

With the measuring tape, set the distance between the lowest point of the ball in the clamp and the middle seam of the gate to h = 7.5 cm. Always place the ball in the clamp in the same way.

The gate should still be high enough to allow you to catch the ball with your hand under it.

Open the clamp as quickly as possible.

Record the time shown on the timer on table 1.

Fig. 8

Check to see that you obtain the same values when repeating the measurement. If this is not the case, check to see that the ball makes contact properly and that you clamp the ball in the same way every time.

If the ball does not meet the beam at the gate or if it touches the gate's enclosure, or if you obtain times greater than 0.5 s, then repeat the trial.

Change the distance between the underside of the ball and the gate's seam to 10, 15, 20, 30 and 40 cm, and repeat the time measurements.

Results

Table 1

h in cm	t in s	t^2 in s^2
7.5		
10		
15		
20		
30		
40		

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h in cm	t in s	t^2 in s^2
7.5	0.123	0.0151
10	0.142	0.0202
15	0.172	0.0296
20	0.199	0.0396
30	0.245	0.0600
40	0.283	0.0801

Evaluation

Question 1

Did the fall time, *t*, double, as the fall distance doubled? Compare the times, *t*, to the corresponding *h* values (7.5 cm and 15 cm, 10 cm and 20 cm, 20 cm and 40 cm).

No, the fall time did not double. When the fall distance doubles, the time increases only by a factor of 1.4.

Question 2

Did the fall time double, when the fall distance quadrupled? Compare the times, t, to the corresponding h values (7.5 cm and 30 cm, 10 cm and 40 cm).

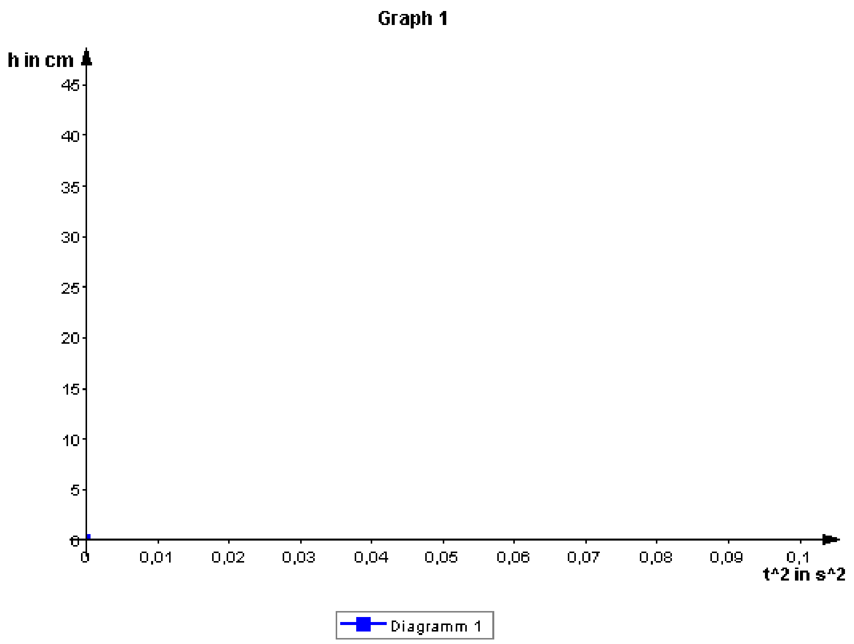
Yes, the fall time doubled as the fall distance quadrupled. The factor is very close to two.

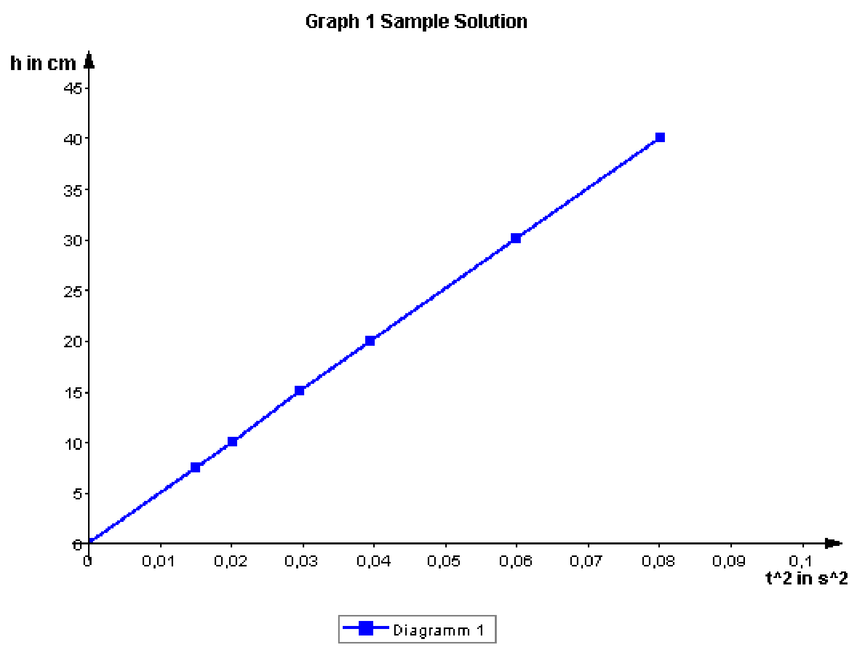
Question 3

Square the values for the time, *t*, and enter them in table 1.

h is ______ to t^2.

See table 1.





Question 4

The height, h, was plotted against t^2 on graph 1. What t and t^2 values correspond to a height of $h = 0$ cm? What relation do you obtain?

See graph 1. The origin of the graph is part of the curve. There is a linear relation, the figure is a straight line. *h* is proportional to t^2.

Question 5

Calculate the proportionality factor $k = \Delta h / \Delta t$. What physical quantity is this factor, *k*, and in what units is it expressed?

$[k] = [\text{cm} / \text{s}^2]$, this is an acceleration. The numerical value is $k = 500\ \text{cm} / \text{s}^2 = 5\ \text{m} / \text{s}^2$.

Question 6

For an accelerated motion with an acceleration *a* for the distance *s*, $s = 1/2\ a\ t^2$. In this case the distance is the height *h*. How large is *a*? What is the cause for the acceleration, and what is it commonly called?

It is $a = 10$ m / s^2. The cause of the acceleration is the earth's gravity. It is called gravitational acceleration and is often labelled *g*.

Question 7

Compare this with the value in the literature for the earth's gravitational acceleration, $g = 9{,}81$ m/s^2.

g = 9,81 m / s^2 deviates from the measured value by 2 %. This is within the range of the measurements' inaccuracy – the ball and the gate cannot be placed any more accurately than within 2 mm in a distance of 10 cm.

Question 8

What would an *h*–*t* graph look like?

An h–t graph looks like a parabola through the origin.