MOTION WITH UNIFORM ACCELERATION

EXPERIMENT PROCEDURE

- **Record distance as a function of time.**
- **Determine the speed at any given point as a function of time.**
- **Determine the acceleration at any given point as a function of time.**
- **Determine the average acceleration as a fit to the data and compare with the quotient of force and mass.**

OBJECTIVE

Record and evaluate motion with uniform acceleration on a roller track.

SUMMARY

When uniformly accelerated motion takes place the velocity at any instant is linearly proportional to the time, while the relationship between distance and time is quadratic. These relationships are to be recorded in an experiment using a roller track with the combination of a spoked wheel employed as a pulley and a photoelectric light barrier.

REQUIRED APPARATUS

Quantity	Description	Number
1	Trolley Track	**1003318**
1	3B NET*log*™ (230 V, 50/60 Hz)	**1000540 or**
	3B NET*log*™ (115 V, 50/60 Hz)	**1000539**
1	3B NET*lab*™	**1000544**
1	Photo Gate	**1000563**
1	Cord, 100 m	**1007112**
1	Set of Slotted Weights, 10 x 10 g	**1003227**

1

BASIC PRINCIPLES

The velocity *v* and acceleration *a* at any given point in time are defined as first and second-order differentials of the distance *s* covered after a time *t*. This definition can be verified experimentally by using differential quotients instead of the actual differentials on a plot with the distance sampled at close intervals where the displacement points *s* are matched with measurements of time t_n. This provides a framework for experimentally investigating, for example, uniformly accelerated motion.

For constant acceleration *a*, the instantaneous velocity *v* increases in proportion to the time *t*, assuming the centre of gravity was initially at rest:

(1) $$v = a \cdot t$$

The distance covered *s* increases in proportion to the square of the time:

(2) $$s = \frac{1}{2} \cdot a \cdot t^2$$

Constant acceleration results from a constant accelerating force *F*, as long as the mass *m* being accelerated does not change:

(3) $$a = \frac{F}{m}$$

These relationships are to be investigated in an experiment using a carriage on a roller track. The carriage is accelerated uniformly because it is pulled by a thread subjected to a constant force, which is provided by a weight of known mass attached to the other end of the thread, see Fig. 1. The pulley for the thread takes the form of a spoked wheel and the spokes periodically interrupt a photoelectric light barrier. A measuring interface is attached which measures the times t_n when the spokes break the beam and sends that data to a computer for evaluation. The evaluation software calculates the distance covered at times t_n, along with the corresponding values for the time and acceleration at that instant.

(4a) $$s_n = n \cdot \Delta$$

(4b) $$v_n = \frac{\Delta}{t_{n+1} - t_{n-1}}$$

(4c) $$a_n = \frac{\dfrac{\Delta}{t_{n+1} - t_n} - \dfrac{\Delta}{t_n - t_{n-1}}}{\dfrac{t_{n+1} - t_{n-1}}{2}}$$

Δ =20 mm: distance between spokes

Measurements are made for various combinations of accelerating force *F* and accelerated mass *m*.

EVALUATION

The evaluation software can display the values *s*, *v* and *a* as a function of time *t*. Applicability of equations (1) and (2) is checked by matching the results with various expressions using the acceleration *a* as a parameter. If m_1 is the mass of the carriage and m_2 is the mass of the weight hanging from the thread. Since the mass m_2 also undergoes acceleration, then the values to be used in equation (3) are:

$$F = m_2 \cdot g \quad \text{and} \quad m = m_1 + m_2$$

This implies: $$a = \frac{m_2}{m_1 + m_2} \cdot g$$

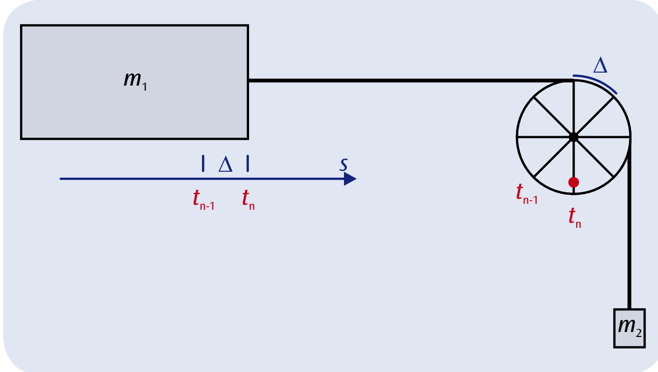

Fig. 1: Schematic illustration of measuring principle

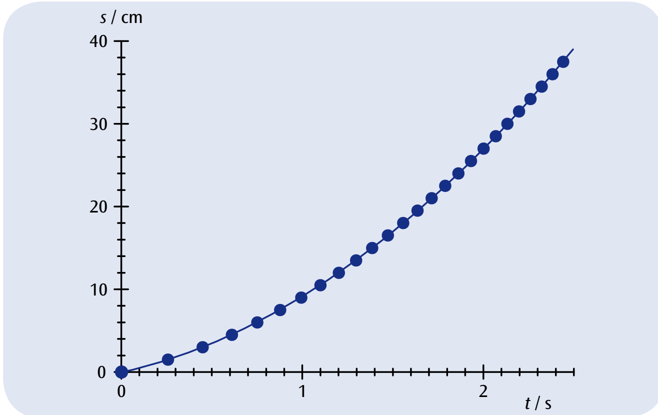

Fig. 2: Distance as a function of time

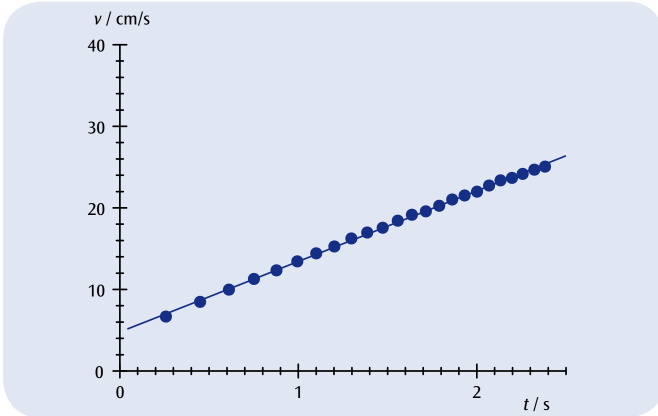

Fig. 3: Velocity as a function of time

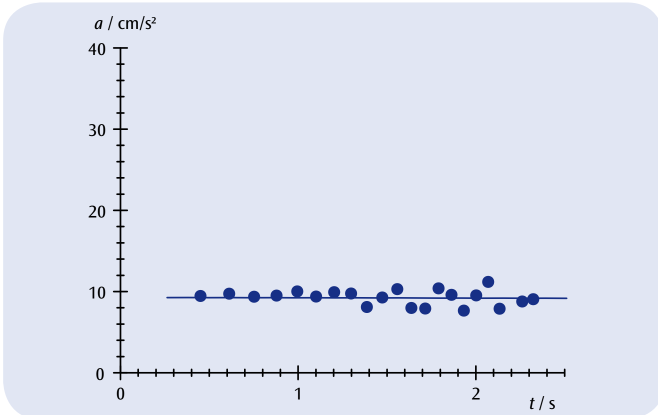

Fig. 4: Acceleration as a function of time