1. Experiments for physics of traffic

|	
classification	physics lesson in secondary degree 1, preferred from the 9th class on
complexity of set-up	easy ☐☒☐☐ complex
students experiment possible	Yes
Objective target/specifics	Although most curricula don't include velocity as a topic for secondary degree 1, this item is handled systematically in nearly all school books. Students often have no exact perception of „velocity". Being necessary for mechanics, it is worth to make it to a subject of discussion. Physic lessons can be a contribution to recognize the danger of road traffic. By sensitising it will be better possible to evaluate the consequences of own behaviour. If students observe the stopping distance in experiments under different circumstances, a conceptual framework will arise, which enables to see and rate perils. Own experience serve as basis. Therefore the aim of this experiment is measuring velocity and the explication of stopping distance and velocity.
needed materials	diverse rods / tripods incline (Fahrrinne) a toy car (Wägelchen) paperclips / gums / some paperboard (Pappfahne) / adhesive strips long ruler (Messlatte) CBL2 photoelectric barrier "Photogate" of Vernier TI83plus; TI92+; TI89 or TI Voyage 200
Circumference of depiction	1.1 measurement of velocity 1.2 to determine the bearing of stopping distance and velocity

1.1 Measurement of velocity

The toy car, which is manipulated with a paperboard, has to be set upon the incline. After releasing the car accelerates and drives through the photoelectric barrier. By means of measured time and the width of the paperboard velocity can be investigated. We use the software DATAGATE for the measurement.
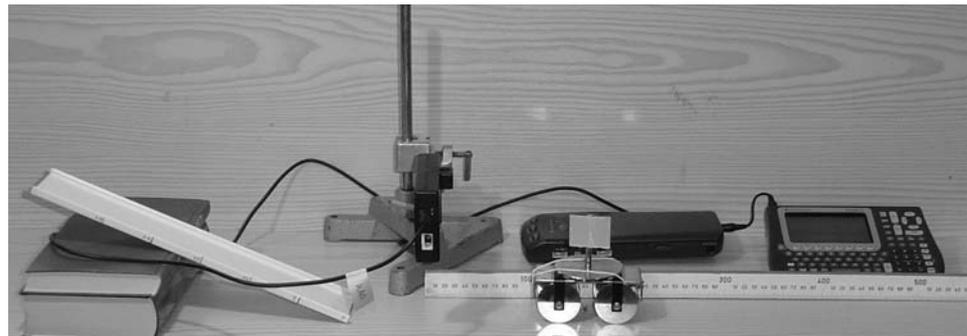
In the program you have to adjust the setting GATE. In this modus you can make several measurements successively.
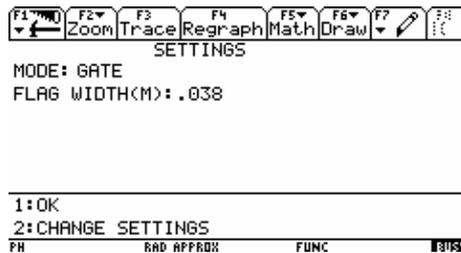
The measured values will be stored and can be edited later in DATA MATRIX EDITOR.

The paperboard had a width of b=3,8cm. Measured time is t=0,0882s . Velocity is accordingly:

$$v = \frac{b}{t} = \frac{0,038\,\mathrm{m}}{0,0882\,\mathrm{s}} \approx 0,43\,\tfrac{\mathrm{m}}{\mathrm{s}}$$

Students should plan and perform this (unspectacular) experiment independently. First of all the item of instantaneous velocity – which can't be measured, but should be measured - is fertile basic physical concepts.

1.2 Finding out connection between breaking distance and velocity
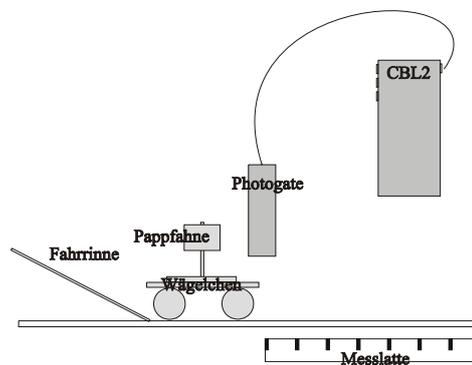
The toy car, which is manipulated with a paperboard and a brake mechanism, is set upon the incline. Breaking distance can be reached by a curved paperclip, which is justified by a gum (see photo below). After releasing the car accelerates and drives through the photoelectric barrier. By means of measured time and the width of the flag velocity can be investigated. The ruler is put from photoelectronic barrier on. It serves the measurement of breaking distance. The brake should be adjusted in a way that the car rolls about one meter at a velocity of $1\frac{m}{s}$. DATAGATE is used for communication with CBL 2.

In the program you have to adjust the setting GATE. In this modus you can make several measurements successively. The measured values will be stored and can be later edited in DATA MATRIX EDITOR.
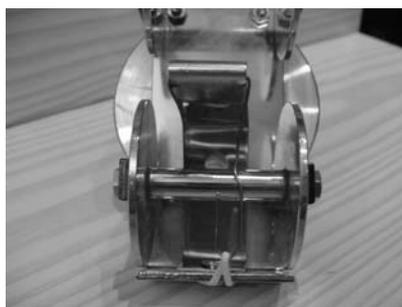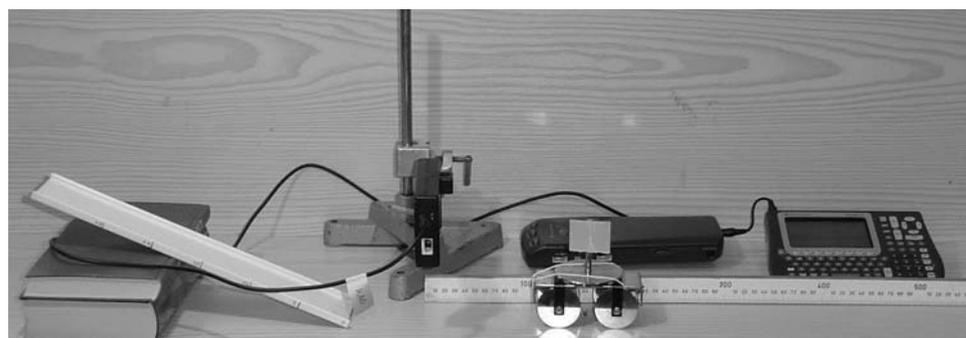
## 1.2 Exploring interrelations between breaking distance and velocity –

example

The following values were measured with the set-up, which has been represented before.

|	N	t/s	v/(m/s)	s/m
	c1	c2	c3	c4
1	1.	.4	.095	.003
2	2.	.15	.2533333	.08
3	3.	.1246	.3049759	.115
4	4.	.2114	.179754	.05
5	5.	.0982	.3869654	.21
6	6.	.1158	.328152	.14
7	7.	.0828	.4589372	.29

c1,Title="N"

The values were already edited in DATA MATRIX EDITOR. Velocity was calculated by the formula from 1.1. In column C4 you find each measured stopping distance. By plotting you get the following picture:

xc:.2533833   yc:.08
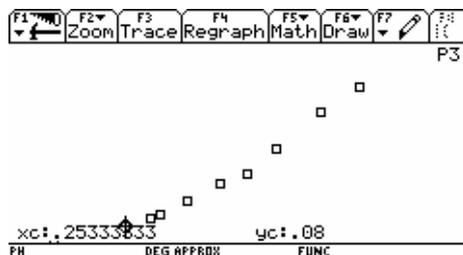
In TRACE-Modus you can head for single measuring points. The pointer represents the pair of measured values $0,25 \frac{m}{s}$ and $0,08m$. Generally the rule

Redoubling velocity,

breaking distance is quadruplicated.

is experimental proved finely with this experiment. The experiment has been tested in the ninth grade for several times. Exploratory, this can be done in a first step with the measuring values. In SCATTER-diagram you find a corresponding pair of measured values, which confirms the relation of stopping distance and velocity.

xc:.5170068   yc:.34
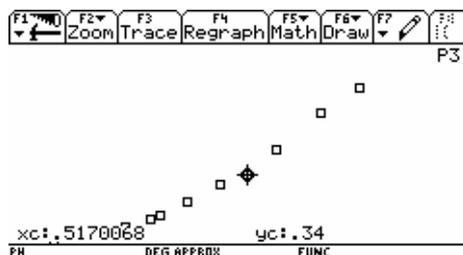
For extended analyses and the development of a model, which can predetermine stopping distance in reliance on velocity, you can use the possibilities of regression of TI calculator.

1.2 Exploring interrelations between breaking distance and velocity – Example

regression parabola

If you choose in DATA MATRIX EDITOR the conforming regression method QUADREG and apply it to column C3 and C4, a parabola is put to data points. Goodness criteria is the optimization of the sum of the squares of the perpendicular distances of points to the parabola – as with linear regression. The following approximation arises from the represented example:
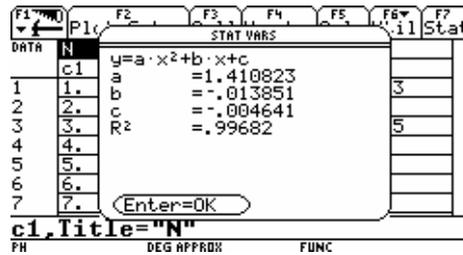
The R^2-value indicates a very good approximation. The lower values for b and c represent the fact that the rule mentioned above applies to the values.
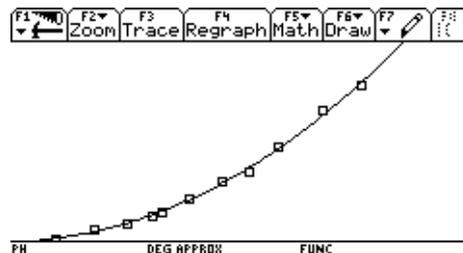
didactic hint

Naturally this method can`t be a subject of discussion in the ninth class explicitly (it would not even be uncomplicated in senior classes). From my point of view it is sufficient to give the hint, that a parabola is determined by data. Students know the extrapolation of data from experiments like the „Law of Ohm". You can also fit v versus s^2 and finally fit a straight line.