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## Operating instructions

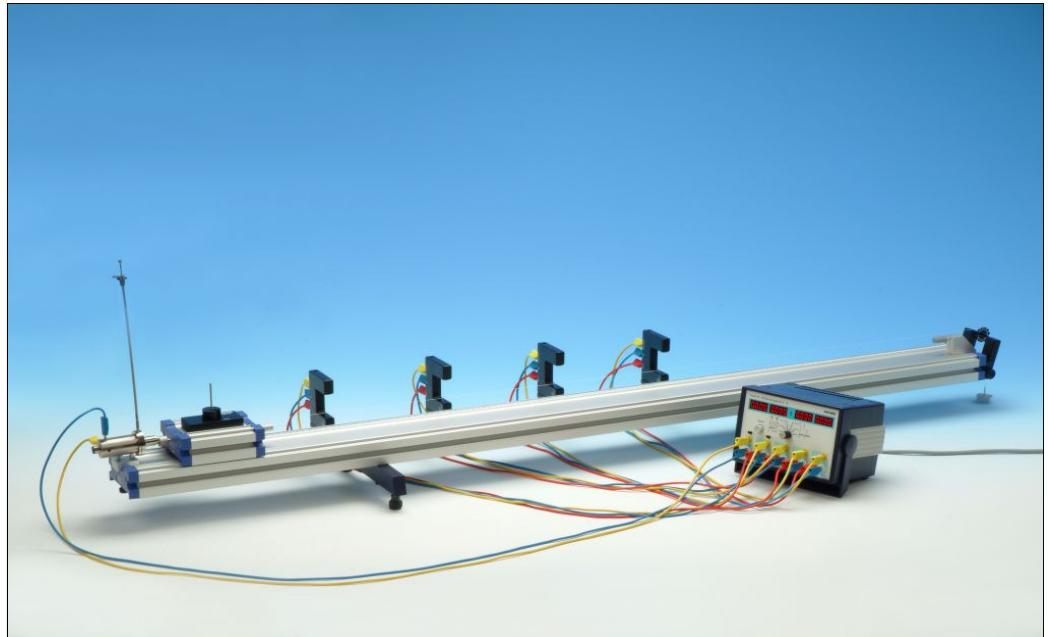


Fig. 1: Demonstration Track, Aluminium, Length: 1.5 m, 11305.00.

## CONTENTS

- 1 SAFETY PRECAUTIONS
- 2 PURPOSE AND CHARACTERISTICS
- 3 PUTTING INTO SERVICE AND HANDLING
- 4 LIST OF EQUIPMENT
- 5 NOTES ON THE GUARANTEE
- 6 WASTE DISPOSAL

### 1 SAFETY PRECAUTIONS



- Carefully read these operating instructions before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Only use the instrument for the purpose for which it was designed.
- Do not start up this instrument should there be visible signs of damage to it or to the line cord.

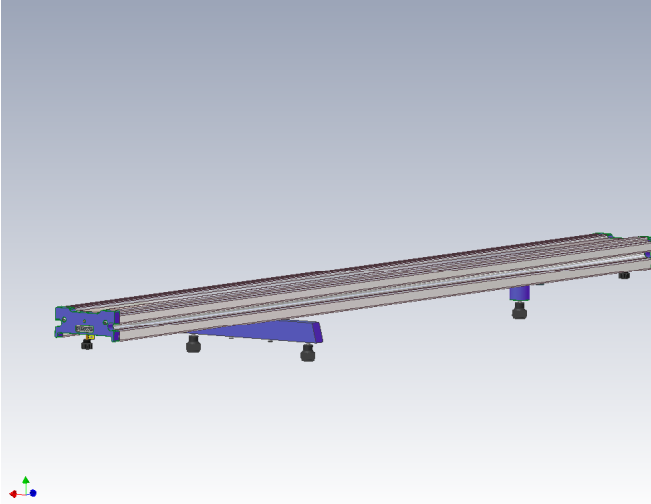
### 2 PURPOSE AND CHARACTERISTICS

The demonstration track 11305.00, together with accessories, is excellently suitable for kinematic and dynamic investigations on straight-line sequences of motions because of the high-quality sapphire bearing of the measurement car, which ensure exceptionally low friction.

The main components in this system are the 1.5 m long aluminium track 11305.00 and the measurement car 11306.00. The numerous accessories allow a great variety of experiments to be carried out. Connections between path, time, velocity and acceleration, as well as the dynamic linkage of these dimensions, can be determined in demonstrative measuring experiments.

Additional electronic measurement devices (light barriers, electronic timer, computer-supported measured value acquisition system) are necessary for time measurement.

## 2.1 Demonstration track, aluminium, $l = 1.5\text{ m}$ , 11305.00



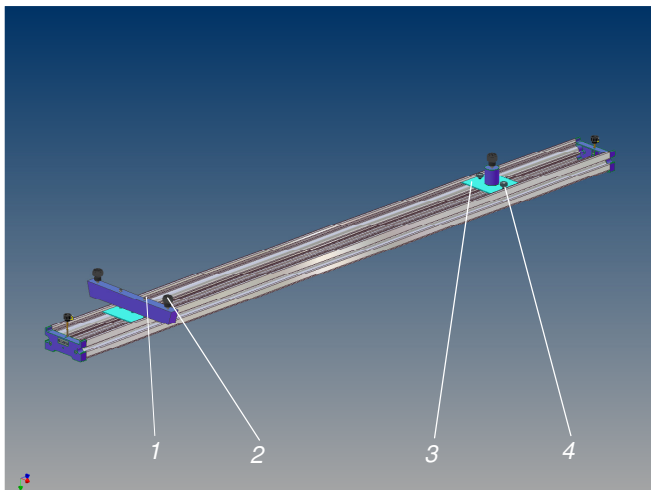
The demonstration track consists of an anodized aluminium, 1.5 m long U-profile (104 x 47 mm). The profile rests in a three-point support on feet which allow the demonstration track to be set up even on smaller benches and whose carrying metal sheets are arranged to be lengthwise displaceable.

Three adjusting screws enable the track to be exactly levelled in all directions. A metal measuring tape, with a two-sided centimetre scale for measurement of the path travelled, is fitted in a groove in the upper side of the roller track.

Milled screws that are screwed into the caps allow e.g. an end fixture device 11305.12, a starting device 11309.00 and/or a deflection pulley holder 11305.11 to be fixed in position.

### Tip:

It is purposeful to leave the end fixture fitted to serve as a stop for the measurement car as long as an experiment does not require a different set-up.



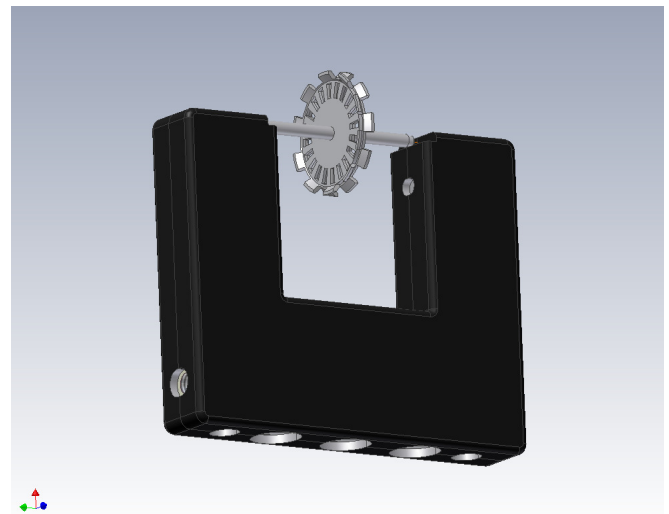
- 1 Mounting screws
- 2 Adjusting screws
- 3 Carrying metal sheet
- 4 Milled screws

The foot with two-point support, the screws necessary for assembly and a hexagonal key are packed loose as delivered. First loosely screw the foot to the carrying metal sheet with the screws supplied (1).

The separating distance of the feet is dependent on the size of the standing area available. For sufficient stability, subtract 20 cm for each foot from the size determined. Position the feet out from the centre to each side according to the determined measure and fix the carrying metal sheet (3) by screwing it tight with mounting screws (1) or milled screws (4).

Position the demonstration track on the feet mounts. The track must be aligned to be as exactly horizontal as possible. This can be achieved using a spirit level or a circular level. The accuracy is decisive for the quality of the experimental results and the running quality of the measurement car.

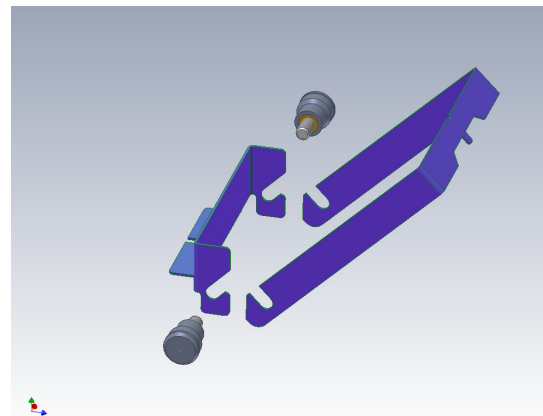
## 2.2 Deflection pulley, 11305.10



The housing of the deflection pulley has the same construction as that of the compact light barrier 11207.20 but has no light barrier function.

Fix the deflection pulley in the small clamps from above under slight pressure. The side thread serves for attachment of a holder for the deflection pulley 11305.11.

## 2.3 Deflection pulley holder, 11305.11

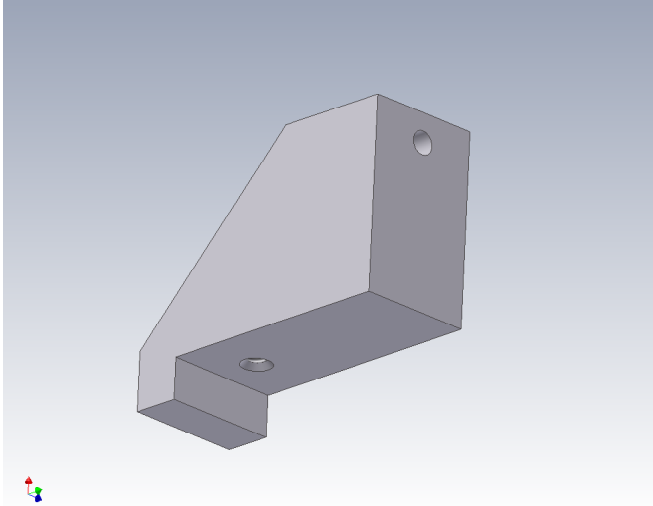


The deflection pulley holder with bracket serves to hold the deflection pulley 11305.10 or a compact fork light barrier 11207.20. The bracket is for the attachment of a silk thread 02412.00. The special screws supplied enable the deflection pulley or a fork light barrier to be clamped between the angles.

*Note:*

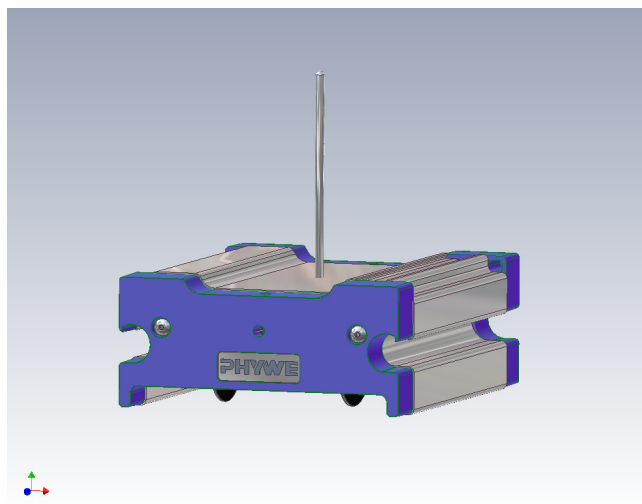
The thread length of the special screws has been exactly suited to the compact fork light barrier. A longer thread could lead to destruction of the light barrier.

## 2.4 End fixture for demonstration track, 11305.12



The end fixture is mounted at the end of the track, with the mechanical stop against the end cap of the track and with the milled screw screwed on from below through the end cap. The front 4 mm borings show to the middle of the track and serve to accept components with 4 mm brush plugs.

## 2.5 Measurement car, sapphire bearings, 11306.00



The measurement car has a length of 130 mm and consists of an anodized aluminium housing with two end caps and a spring-bearing undercarriage, the chassis. At the front of the end caps there is central 4 mm borehole for the fastening on of components with 4 mm brush plugs and a vertical boring with thread for the fitting on of further accessories.

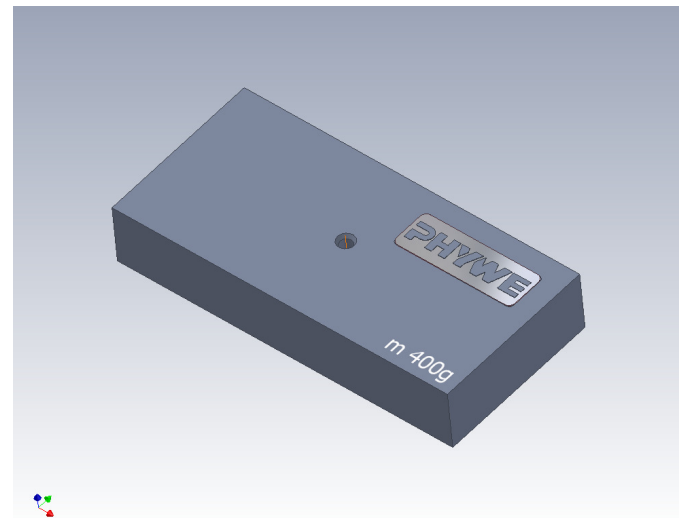
The extremely low friction of the measurement car has been attained by the use of high-quality precision sapphire bearings in the construction of the wheel set. These allow the car to roll along the track almost frictionless. To protect the high-quality bearings from damage or overloading, the wheel sets are so arranged on the chassis that they only have ground contact on the track 11305.00, otherwise, on level surfaces, the measurement car stands on the housing so that the bearings are protected. Just as with expensive watches, too great a shock is to be avoided despite overload protection.

Should the measurement car be put down too hard on the track, or be overloaded by too much additional weight, then the bearing is protected by the flexible suspension of the chassis, so that the measurement car stands on the track on its housing. The mass of the measurement car with inserted diaphragm 11308.00,  $l = 100$  mm and with the two parts that are typically plugged on (e.g. plate with plug and fork with plug) is 400 g. An increase in mass can be made with the adding of additional weights that have a central hole (400 g weight for the measurement car, 11306.10; 50 g slotted weight, 02206.01; 10 g slotted weight, 02205.01). Fixing of the weights is made via the threaded rod supplied, that screws into the top surface of the car housing.

*Note:*

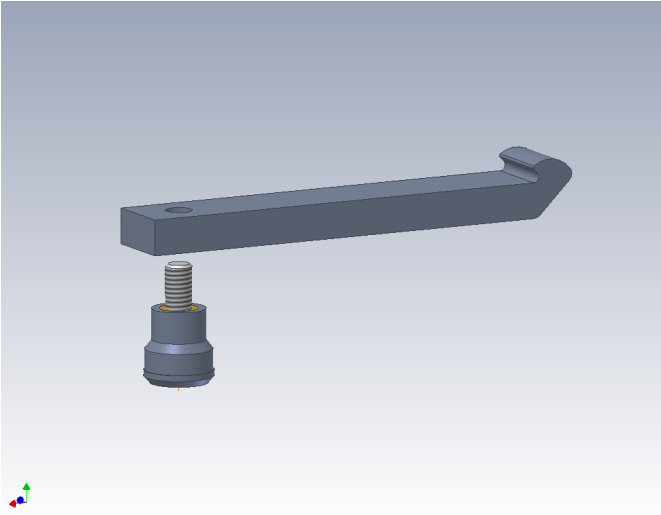
Please keep the packaging material for the measurement car. The top padding serves to protect the measurement car during transport and also when it is not in use.

## 2.6 Weight for measurement car, 400 g, 11306.10



This weight has a mass of 400 g and is used to increase the weight of the measurement car. The central hole allows the weight to be fitted on via the threaded rod screwed into the measurement car.

## 2.7 Light barrier holder, 11307.00

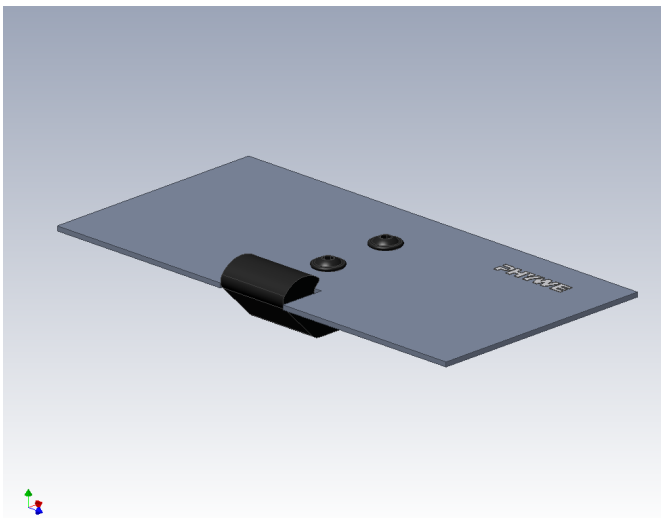


The light barrier holder, 11307.00 is held by this black anodized aluminium holder, screwed tight by the special screw provided. To fit the holder on, bring the diaphragm to the measurement car at an angle of  $45^\circ$  from the side, engage the diaphragm centrally and then turn it to the resting position.

### Note:

The thread length has been exactly suited to the compact fork light barrier 11207.20. A longer thread could lead to destruction of the light barrier.

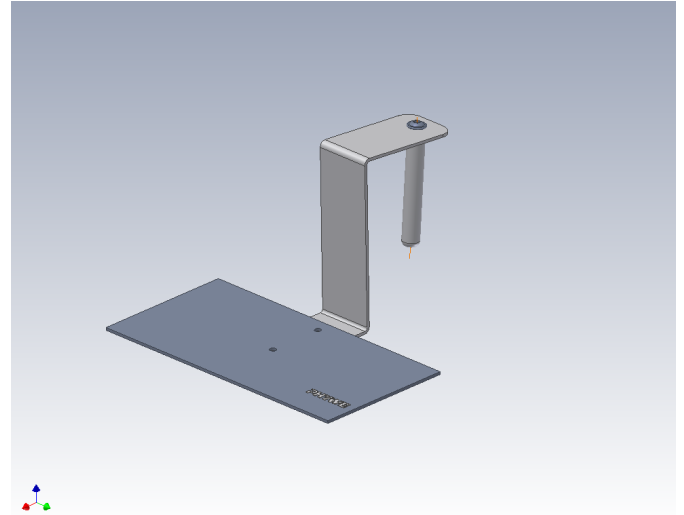
## 2.8 Diaphragm for measurement car, 11308.00



The black plastic diaphragms,  $l = 100$  mm, are fitted to the measurement car with the aluminium holder from the side between the end caps and by swivelling them into the longitudinal groove. Bring the diaphragm to the measurement car at an angle of  $45^\circ$  from the side, engage the diaphragm centrally and then turn it to the resting position.

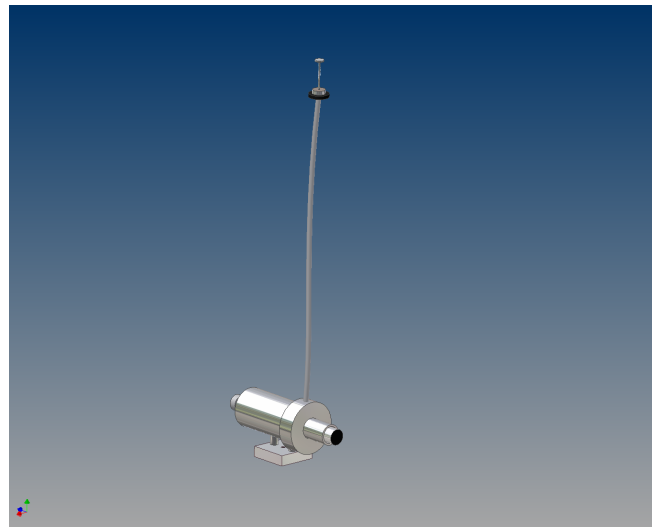
The diaphragms serve to control the light barrier electronic measurement system arranged along the track (e.g. electronic digital counter, 6 decades, 13603.93; Timer 4-4 with USB-interface, 13604.99; Cobra3 Basic-Unit, 12150.00).

## 2.9 Diaphragm for experimental car, 11308.10



The black plastic diaphragm,  $l = 100$  mm, is fitted with the aluminium holder in the plastic housing of the motor driven car (11061.00) from above. The diaphragm serves to control the light barrier electronic measurement system arranged along the track (e.g. electronic digital counter, 6 decades, 13603.93; Timer 4-4 with USB-interface, 13604.99; Cobra3 Basic-Unit, 12150.00).

## 2.10 Starting device for the demonstration track, 11309.00



The starting device is used in combination with demonstration track 11305.00. It serves on the one hand to give defined, unchanging starting pulses and on the other hand to fix a measurement car in the starting position and then, without giving a pulse, to release it by operating a triggering mechanism and synchronously starting an electronic timer.

This device is a catapult that can be screwed to the track. A coil spring inside the cylindrical housing of the catapult accelerates a rammer when the trigger is operated. The final velocity of the rammer can be varied in three steps with different span distances.

Simultaneously with the triggering, a switching contact is closed; this switching process serves to start a timer. Prior to the start of the experiment, the measurement car on the demonstration track is fixed to the starting device by means of a

of a magnet with plug, 11202.14. Triggering is carried out with the release cable supplied.

The starting device is fixed to the end cap at the end of the track with a milled screw. According to the application, it is to be mounted with various orientations. The rubber feet recessed in the screwed-on plate increase friction and so prevent turning of the starting device.

For the transfer of the starting pulse to the measurement car, the piston-shaped rammer must point to the middle of the track. The rammer is pressed in to the wanted arresting position and the measurement car coupled to the rammer with the plugged-in magnet.

The measurement car can be started by means of the release cable. On repeating the experiment under the same conditions, i.e. with the same measurement car weight and the same spanning of the spring or arrest position, the same initial velocity is given within narrow error limits.

The measurement car should be released from the starting position without any start pulse (e.g. in experiments with uniformly accelerated motion). Hereby, the starting device is to be so mounted on the track, that the pipe nozzle opposed to the rammer points to the middle of the track.

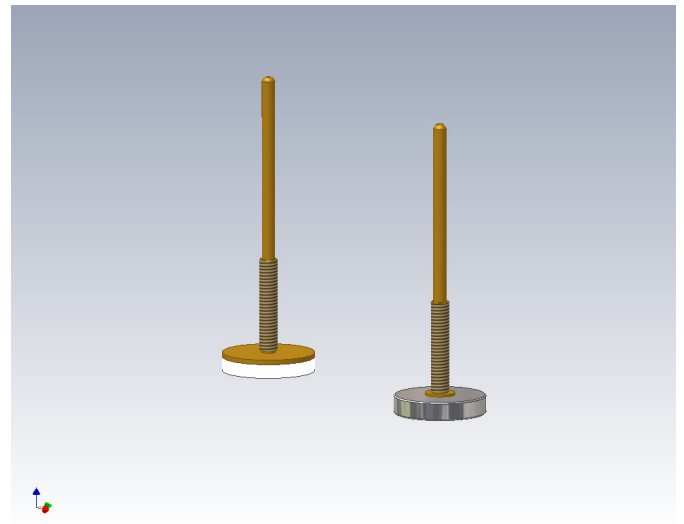
Press the rammer in to the middle arresting position and push the measurement car with plugged-on magnet fully to the pipe nozzle. In this position there is only a very small air gap between the ferromagnetic cylinder inside the pipe and the magnet, so that the measurement car is magnetically fixed to the starting position. On operating the trigger, the ferromagnetic cylinder jumps back to its initial position and releases the measurement car.

### **Connection of an electronic timer**

There are two 4 mm sockets at the side of the housing that enable an electronic timer to be connected. In live condition, both sockets are electrically isolated from each other. At the moment triggering occurs, the sockets are short-circuited. The short-circuiting is maintained as long as the starting device is at the arrest position.

All PHYWE digital counters could be used as timer. The starting device is in each case to be applied to the "Start" gate input. Please refer to the appropriate operating instructions to be sure that the timer will be started on closing the contact in the starting device.

## **2.11 Brake set for measurement car, 11310.00**



The brake set consists of two-parts, a felt brake and a magnetic brake. For the one, a free riveted plate with a felt button is mounted on the threaded rod, for the other a high-quality neodymium magnet.

### **Important notes on handling the neodymium magnet:**

#### **Liability**

Phywe Systeme GmbH & Co. KG does not accept any liability for damage that occurs through improper handling of neodymium magnets. With the purchase of the neodymium magnet, you confirm that you have read this warning and accept it.

#### **Brittleness, danger of splintering**

NdFeB Magnets are not made from metal but manufactured through sintering and can therefore fracture. Magnets most frequently fracture when two of them collide uncontrolled. It is imaginable that splinters could fly from such a collision.

#### **Wear or splintering off of the surface coating**

The magnets are coated with a thin nickel coating. This coating can wear off in the course of normal use.

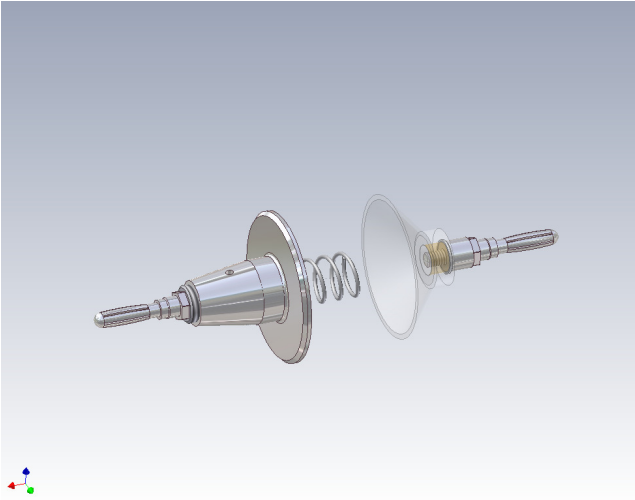
#### **Magnetism**

NdFeB Magnets are much stronger magnetically than "ordinary" magnets. It is therefore necessary to keep them a good distance away from all instruments and objects that could be damaged by magnetism. Examples of such instruments and objects are : Television and computer monitors, credit cards and EC-cards, computers, floppy discs and other data carriers, video tapes, mechanical watches, hearing aids and loudspeakers.

#### ***Important!***

***Cardiac pacemakers can be destroyed by a large magnet or be switched to test-operation - it is absolutely necessary that sufficient distance is held here (1 m)!***

## 2.12 Explosive start device, 11311.00

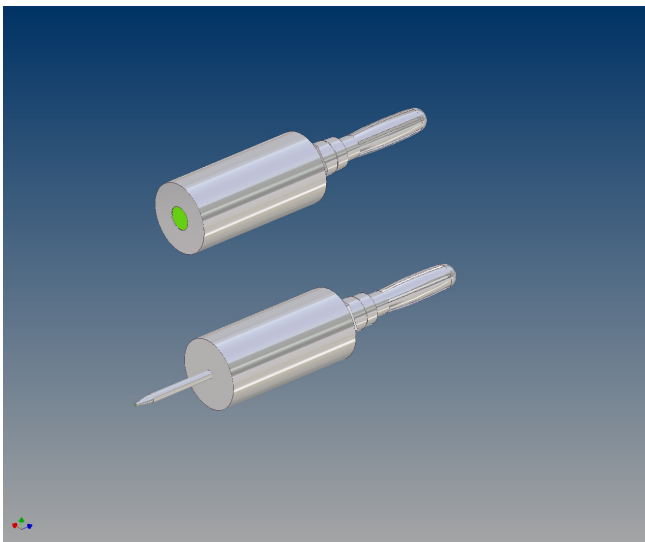


The explosive start device consists of two parts. The first part is an anodized aluminium housing with a loosely engaged helical coil compression spring and a 4 mm brush plug. The second part is an electrical suction apparatus with a 4 mm brush plug.

Air is laterally displaced by the centric approach of the suction apparatus on the level surface of the round aluminium housing against the spring pressure of the compression spring. The ambient air pressure prevents repellment of the suction apparatus despite the spring pressure.

The release of the stored spring energy results from the delayed ventilation of the suction apparatus through a borehole in the aluminium housing. Ventilation up to pressure equilization through a restriction washer takes place within approx. 3 to 5 seconds. At pressure equilization, the stored spring energy is released and causes the other side to "explode".

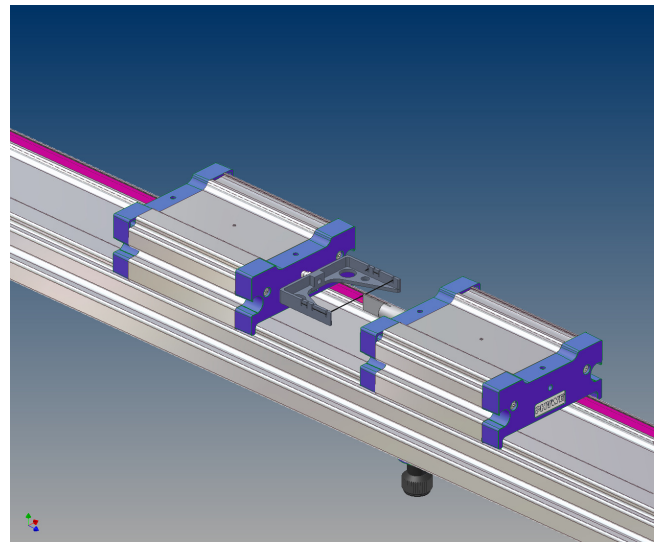
## 2.13 Tube and needle with plug, 11202.05 and 11202.06



For inelastic collisions, the plug-in elements are plugged into the two front sides of the measurement cars that are opposite to each other. On collision, the needle bores into the plasticine filling of the tube, whereby the two cars are tightly coupled to each other.

The needle and tube plug combination can also be used to hold a measurement car subjected to motion at the end fixture.

## 2.14 Fork and plate with plug, 11202.08 and 11202.10

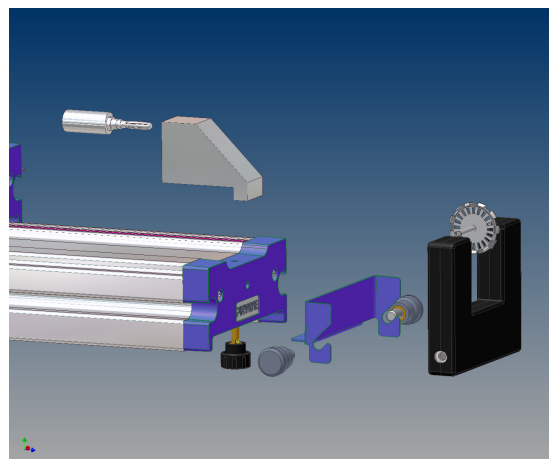


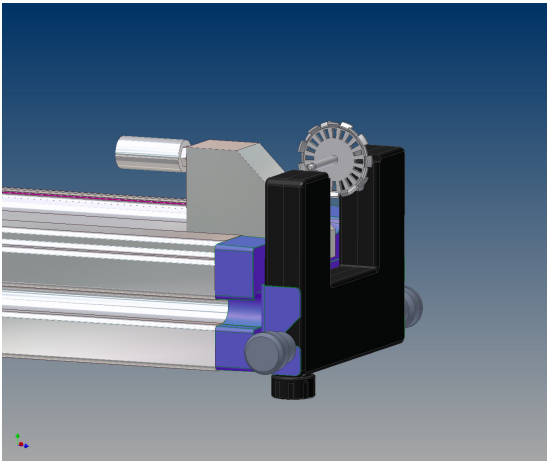
The fork with rubber band is used for elastic collisions. For this, the fork and the plate are plugged one to each of the front sides of two measurement cars facing each other.

In elastic collisions, the plate is the counter element to the fork. The fork with plug has 4 slots for clamping of a rubber band from 11202.09. The rubber band must not sag, but also not be too tightly stretched.

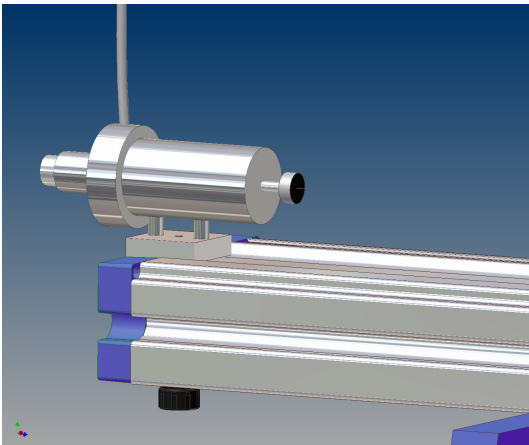
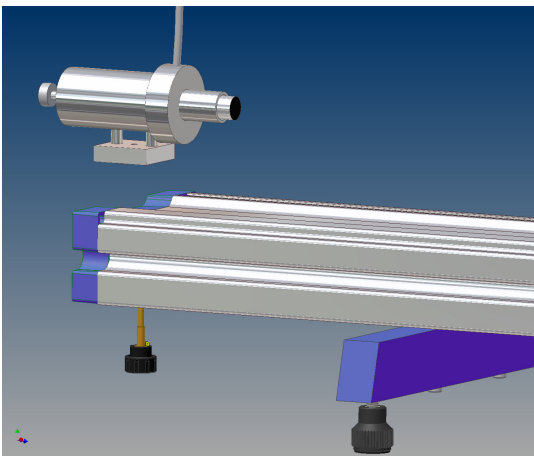
## 3 PUTTING INTO SERVICE AND HANDLING

Place the track on an as horizontal as possible, flat and stable surface. Prior to starting to work with it, fix an end fixture 11305.12 to one end of the track and, if available, a deflection pulley holder 11305.11 using a milled screw.

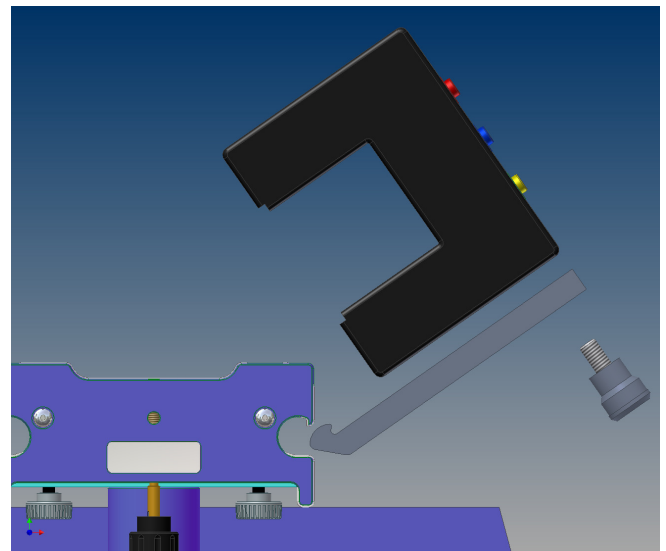




Usually, an end fixture or a starting device is to be fitted on the other end.

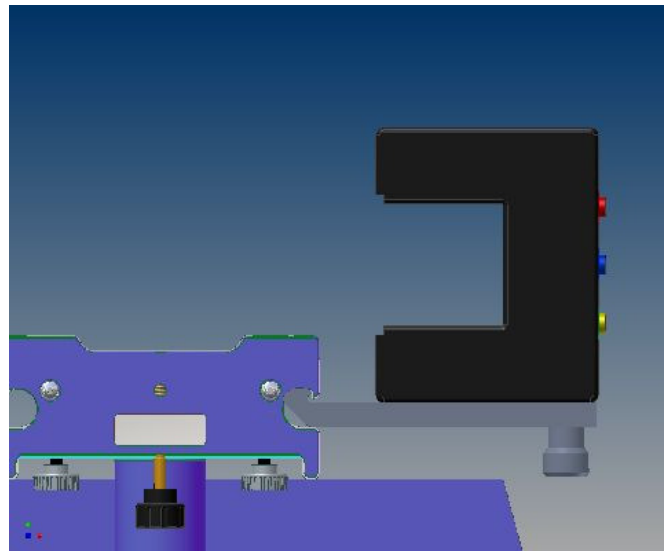


As concluding preparation, the holder for the fork light barrier 11307.00 can be swivelled into the track profile from the side. The compact fork light barrier 11207.20 can then be screwed tightly to the holder with the accompanying milled screw.



*Note:*

The thread length of the milled screw has been exactly suited to the compact fork light barrier 11207.20. A longer thread could lead to destruction of the light barrier.



After the basic assembly work has been carried out, align the track as horizontally as possible. A spirit level or a circular level can be used for this.

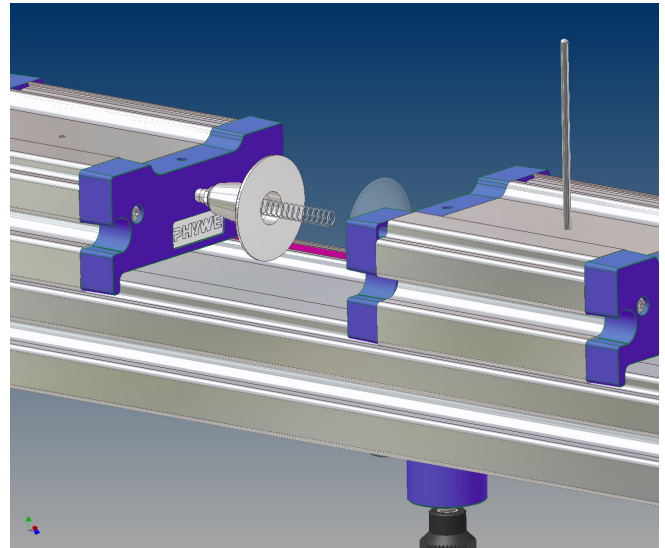
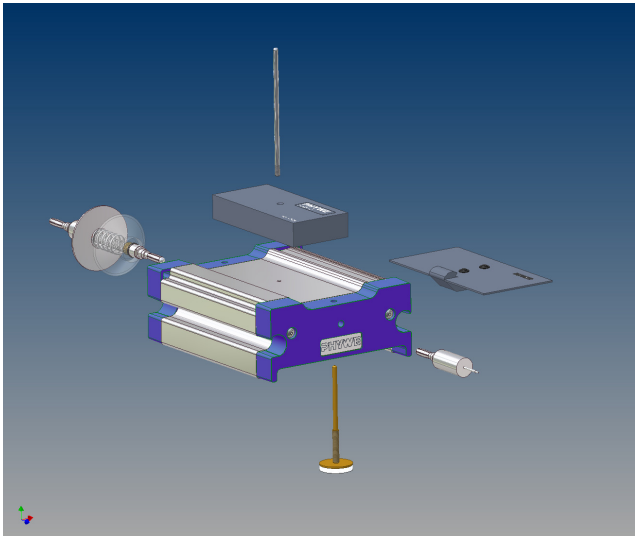
Lay the spirit level on the track parallel to the foot with two-point support and level by turning the adjusting foot in the middle. Now place the spirit level lengthwise on the middle of the track and again level. Repeat this process if necessary.

The accuracy of the adjustment is decisive for the running quality of the measurement car and so also for the quality of the experimental results. With a track that has been aligned well, the measurement car will roll along the measurement distance extensively free of loss of energy, without touching the sides and without a scratching noise.

The measurement car can be equipped with various accessories for diverse experiments. The central borehole in the end caps serves to hold components that are mounted on a 4 mm bush plug. Diaphragms 11308.00 can be swivelled be-

tween the end caps into the lengthwise side grooves.

The threaded rod that is supplied with the measurement car serves to fix additional weights. The felt or magnetic brake are fitted into the measurement car from below through the borehole in the end cap.

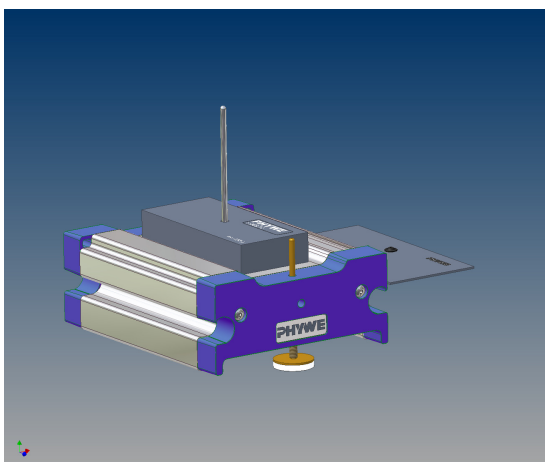
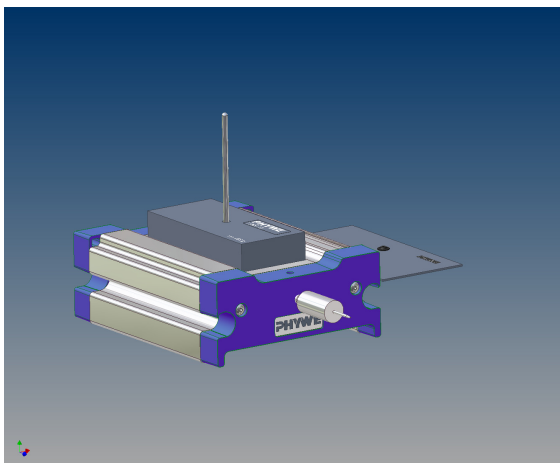


Two measurement cars can be started with a time delay and without touching by the two-part explosive start device. For this, the aluminium housing with the compression spring and the 4 mm plug is plugged on the one measurement car and the elastic suction apparatus on the other.

Press the two cars vertically on the track for the housings to come to a mechanical stop. The two measurement cars can now approach each other concentrically until the elastic suction apparatus bears against the spring pressure just on the round aluminium housing.

By pressing the suction apparatus on the housing base, air is laterally displaced, the ambient air prevents repulsion of the suction apparatus despite the spring pressure. Position the measurement car appropriately to the fork light barrier and let it top out.

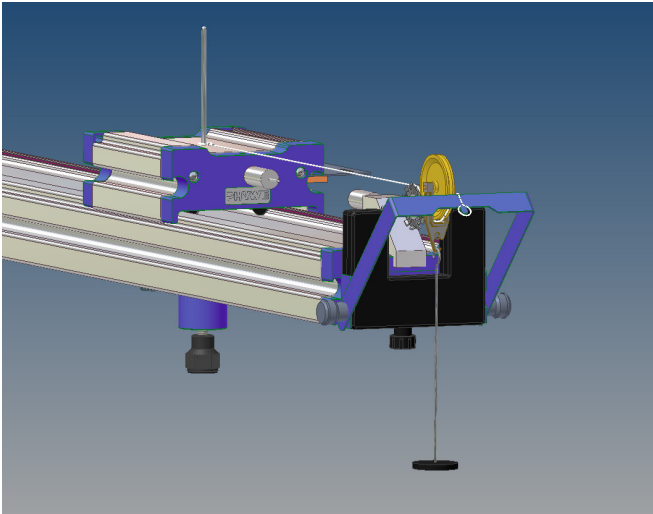
The elastic suction apparatus is vented for a period of from 3 to 5 seconds, whereby air enters through a borehole behind which there is a restriction washer. When pressure has been equalized, the stored energy in the spring is released and causes the measurement cars to "explode" away from each other in the two directions.



In the cap, there is a thread at about half-height, turning the axis enables the appropriate height or air gap between track and brake to be varied.



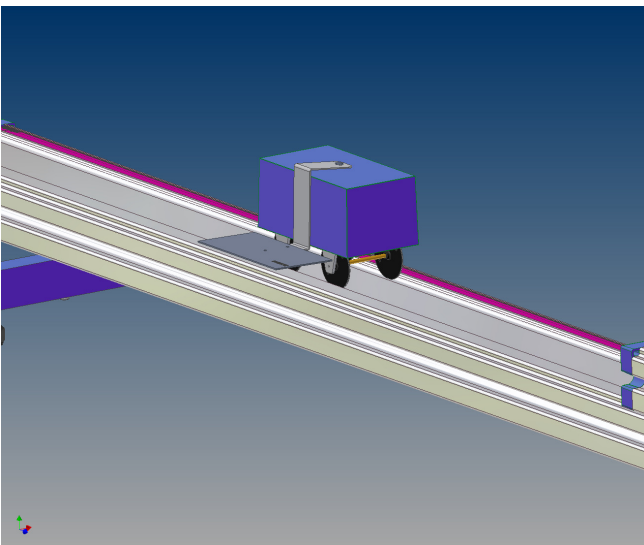
Should the acceleration of the measurement car result from a weight that is connected to the car with a thread, then the acceleration path that can be utilized normally corresponds to the height of the track above the floor. This limitation can be got around by the use of a lose roller, and the acceleration path so be doubled. For this, mounting of the bracket for the deflection pulley holder 11305.11 is required.



Detach the milled screw provided to mount the bracket between the holder and the milled screw. There is a cant at the free end of the bracket that comes on the end cap to the attachment and so hinders tilting of the bracket due to the pull across the rotation point.

For acceleration, a silk thread 02412.00 is tied between the measurement car and the bracket. A weight holder 02204.00 is hung on a lose roller and hung on the thread.

For accurate measurements, as the nominal masses of the measurement car, the diaphragm 11308.00 and the needle with plug are subject to a certain tolerance, the mass to be accelerated should be weighed. If appropriate, the mass can be trimmed with an additional slotted weight.



The motor driven test car, 11061.00, serves for the experimental determination of uniform motions. This car, that is driven by a battery powered motor, has a continuously variable gear change and can be moved at selectable velocities.

The continuously adjustable velocity range is approx. 10...30 cm/s. The car can be switched to drive forward and backwards. (Please refer to the enclosed operating instructions for the operation of the measurement car). For time measurements, the black plastic diaphragm 11308.00 of edge length  $l = 100$  mm can be fitted into the plastic housing of the motor driven car with the dowel on the aluminium holder.

The diaphragms serve to control the electronic light barrier timer system arranged along the track (e.g. electronic digital counter, 6 decades, 13603.93; Timer 4-4 with USB-interface, 13604.99; Cobra3 Basic-Unit, 12150.00).

## 4 LIST OF EQUIPMENT

### 4.1. Basic equipment

Demonstration track, aluminium, $l = 1.5$ m		11305.00
End fixture for demonstration track	2x	11305.12
Measurement car, sapphire bearings		11306.00
Light barrier holder	4x	11307.00
Light barrier, compact	4x	11207.20
Deflection pulley holder		11305.11
Deflection pulley		11305.10
Diaphragm for measurement car, $w = 100$ mm		11308.00
Silk thread		02412.00

### 4.2. Further supplementary parts

Starting device		11309.00
Weight $m = 400$ g	2x	11306.10
Test car, motor driven		11061.00
Diaphragm for experimental car		11308.10
Brake set for measurement car		11310.00
Explosive start device		11311.00
Tube with plug		11202.05
Needle with plug		11202.06
Hook with plug		11202.07
Fork with plug		11202.08
Plate with plug		11202.10
Holder with plug		11202.11
Holding magnet with plug		11202.14
Pulley, movable, $d = 40$ mm, with hook		03970.00
Weight holder for slotted weights		02204.00
Slotted weight, 10 g		02205.01
Circular level with mounting, $d = 35$ mm		02122.00

### Not shown:

(Both counters supply the 5 V voltage required for operation of the light barriers)

Universal Counter		13601.99
Digital counter, 6 decades		13603.93
Timer 4-4 with USB-interface		13604.99
Cobra3 BASIC-UNIT		12150.00
Power supply 12 VDC/2 A		12151.99
Cobra3 Software Timer/Counter		14511.61
Plasticine		03935.03
Rubber band for fork with plug		11202.09
Cobra4 Sensor-Unit Timer/Counter		12651.00
Cobra4 adapter for Sensor-Unit Timer/Counter		12651.01
Cobra4 USB-Link		12610.00
Cobra4 Wireless-Link		12601.00
Cobra4 Wireless Manager		12600.00

## **5 NOTES ON THE GUARANTEE**

We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU. Excepted from the guarantee are damages that result from disregarding the Operating Instructions, from improper handling of the instrument or from natural wear.

The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and alterations to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.

## **6 WASTE DISPOSAL**

The packaging consists predominately of environmental compatible materials that can be passed on for disposal by the local recycling service.

Please contact your municipal administration for information on the disposal of instruments.