CENTRUM
NAUKI
KOPERNIK

# Catalogue of exhibits

# EXHIBITS

Every day thousands of visitors come to our exhibitions.
We have observed them and gathered their opinions concerning all exhibitions, exhibits and learn how to design and build the best exhibits. This is our competitive advantage over any producer of interactive devices and educational materials.

The document presents 31 exhibits, which are the orginal selection of the Copernicus Science Centre.

Exhibits that we present in our offer not only give people a chance to discover new phenomena, but also to improve their skill of observation and be amazed with nature and capabilities of humans. They give opportunity to reflect on our limitations and the role of science in overcoming them.

Exhibits can be used by individual visitors, as well as engage a group of people. They can be easy to use and illustrate a simple phenomenon, as well as more sophisticated ones enable a deeper, multi-level exploration.

# OUR EXHIBITS:

1. Precisely show authentic natural phenomena – a real experience and not just its model.
2. Are visually attractive and engaging and cause emotions.
3. Are characterised by minimalistic design, with uniform cases and colours, which make visitor focused on the very phenomenon and doesn't distract them with other factors.
4. Are safe, intuitive to use and durable.

We focus on key elements: precise presentation of the given phenomenon and making the visitor's experience as real as possible.

Each exhibit underwent numerous internal tests and was then repeatedly tested with visitors.

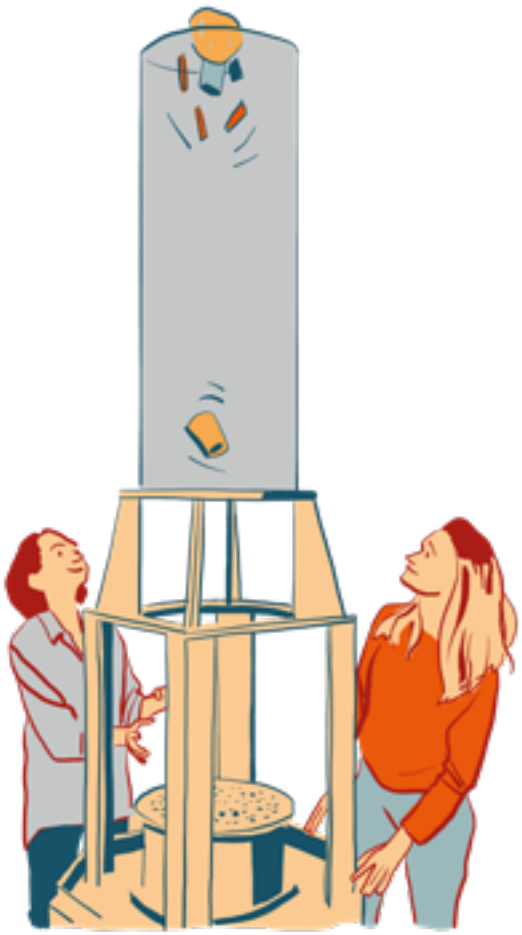
We have prepared exhibits with wide audience in mind, ranging from children, to teens, adults and seniors. This way you can reach different target groups and convince people of all ages that science is a fascinating adventure.

# Fan

## Test your flying constructions!

Simple but lots of fun. The exhibit consists of a blower with a transparent tube and a box full of materials for experiments. Users create their own flying structures and see how air sets them in motion — they can float, fall or spin.

**Keywords:** falling, gliding, flying, gravity



### Construction of the exhibit

A transparent tube mounted on a wooden structure above a fan and a box with various small items for experimenting and building flying structures. Several people can experiment at the same time.

### Technical information

**Dimensions:** width: 100 cm, depth: 100 cm,

**height:** 280-340 cm

**Consumable materials:** ping-pong balls, skewer sticks, rubber bands, A4 sheets of paper, ice cream sticks, straws

**Accessories:** scissors

**Power:** 230V main

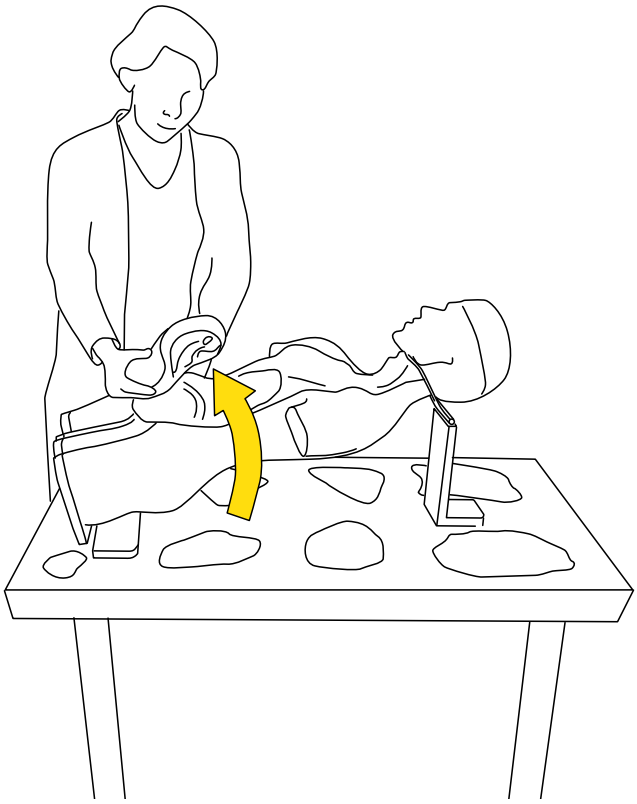
# Fan

# Man puzzle

## Tight-fitting but everything fits!

Place the organs in the manikin: lungs, heart, liver, pancreas, stomach, intestines, kidneys, bladder, brain, eye, etc. Since they are tightly packed, there is only one correct way to arrange them. But that's not all, because on an additional touch screen you can learn everything about the internal systems of the human body and the functions of individual organs.

**Keywords:** human, model, internal organs, digestive system, respiratory system, genitourinary system, cardiovascular system, nervous system, brain



### Construction of the exhibit

Two tables. On the first table, there is a mannequin and removable models of the main human organs. On the second table, there is a touch screen with descriptions of the functions of individual organs. The exhibit allows several people to experiment at the same time.

### Technical information

**Length:** 120 cm

**Width:** 80 cm

**Table height:** 56.5 cm

**Total height:** 86.5 cm

**Power supply:** none

**Consumable parts:** mannequin and its components

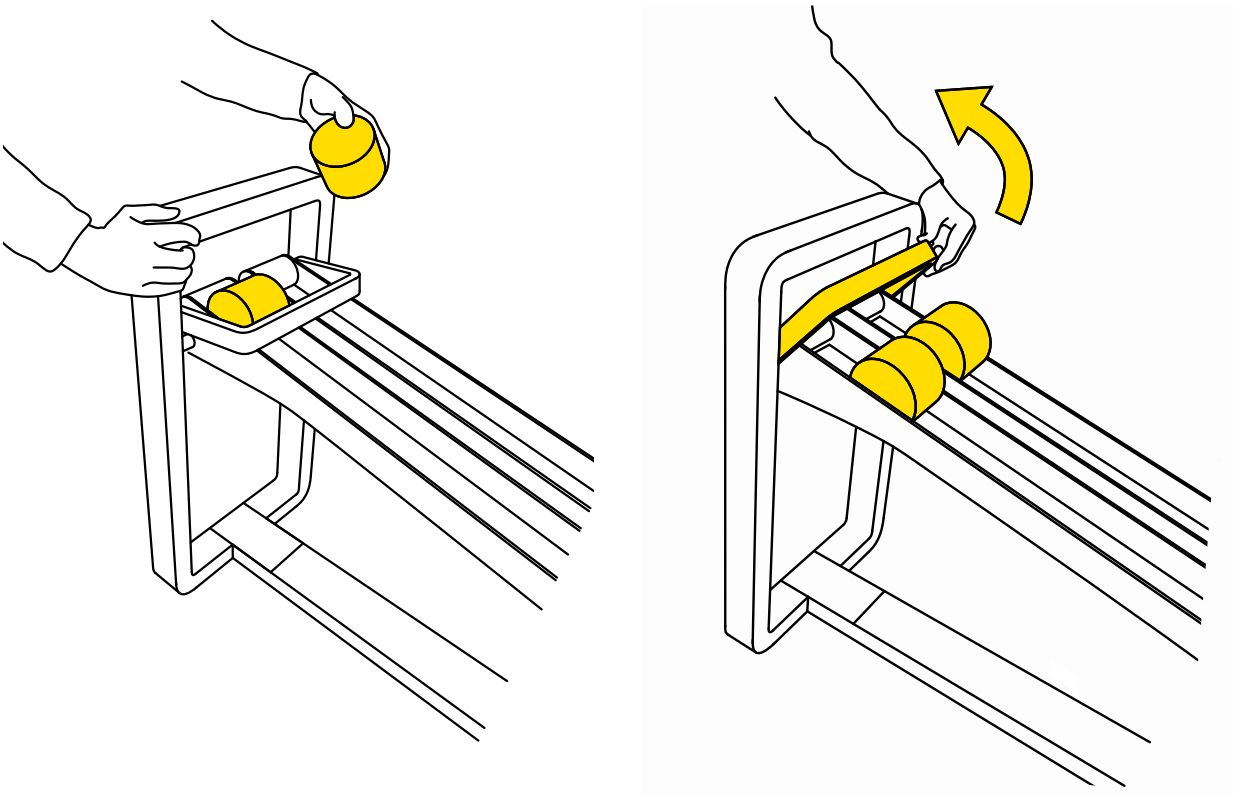
# Man puzzle

# Roller racing

## Who’s first down there?

Two seemingly identical rollers, yet one rolls faster than the other! The rollers are made of the same material, have the same diameter and weight. However, in one roller, the weight is distributed evenly around the circumference, while in the other, most of the weight is concentrated near the axis.
As a result, they differ in their moment of inertia, which affects the speed at which they pick up speed when rolling down a plane.

**Keywords:** moment of inertia, kinetic energy of translational motion, kinetic energy of rotational motion, potential energy



### Construction of the exhibit

The exhibit consists of two identical inclined planes positioned parallel to each other and two rollers. The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 189 cm, depth: 56 cm,

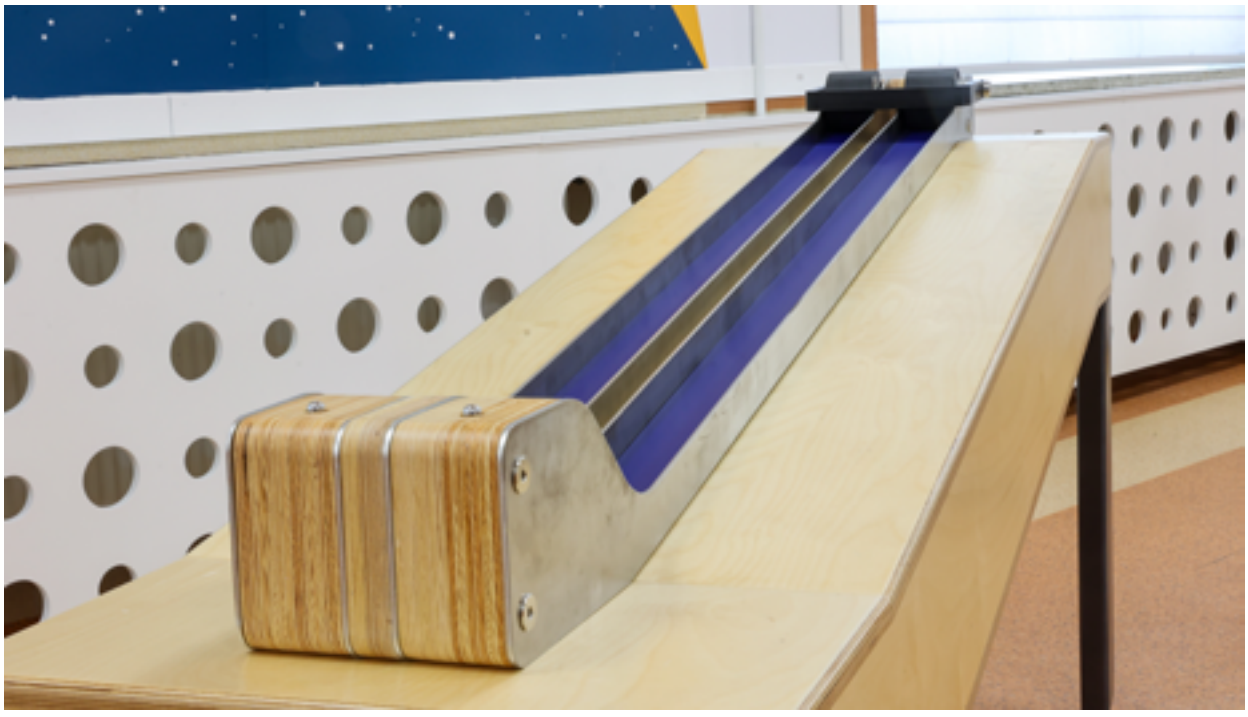
**height:** 93 cm

**Consumable materials:** -

**Accessories:** -

**Power:** -

# Roller racing

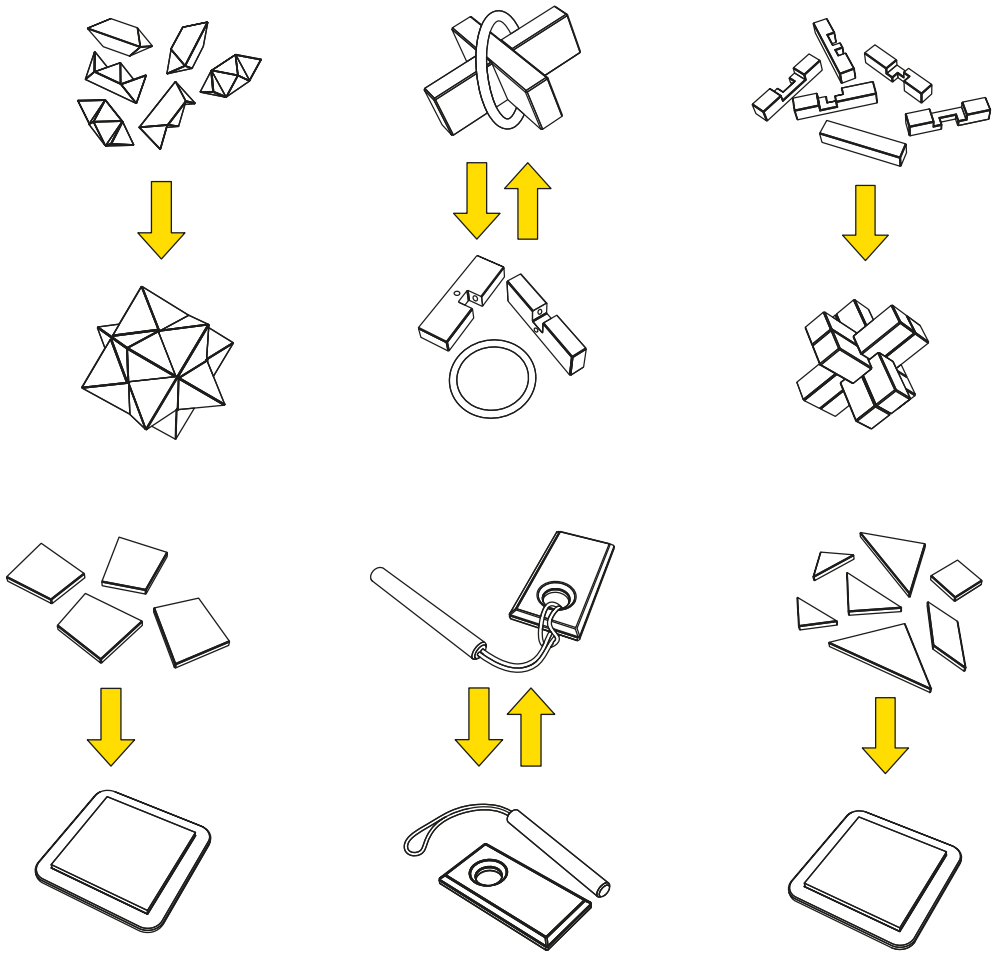


# Mathematical puzzles

## Improve your observation skills, patience and 3D imagination.

Some of the puzzles are jigsaw puzzles, while others require separating elements. Solving some requires perceptiveness or spatial imagination, while others require finding an algorithm and repeating it until the solution is found.

**Keywords:** puzzle, algorithm, jigsaw



### Construction of the exhibit

The exhibit consists of a table with eight stations for solving different puzzles. The exhibit allows several people to experiment at the same time (one person per stand).

### Technical information

**Dimensions:** width: 160 cm, depth: 80 cm,

**height:** 113 cm

**Consumable materials:** -

**Accessories:** puzzle elements, stools

**Power:** -

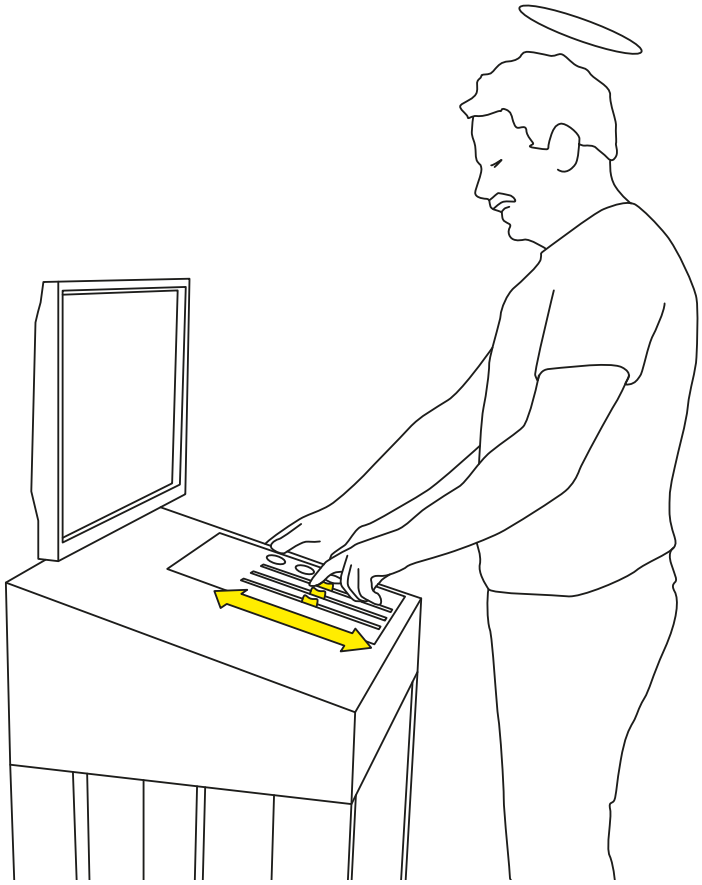
# Mathematical puzzles

# Vanishing cat

## Cats and RGB? Now that’s fun!

The exhibit demonstrates the principles of mixing RGB primary colour palette (red, green, blue). A cat appears on the screen in a randomly selected colour. The user must adjust the intensity of the light so that the cat blends into the background. The light is controlled by sliders on the control panel. When the user is satisfied that the colour has been adjusted correctly, they can use the ‘check’ button.

**Keywords:** : colours, colour mixing, RGB, lighting intensity



### Construction of the exhibit

The exhibit consists of a screen and a control panel with three sliders to adjust the intensity of red, green and blue light.

The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 53 cm, depth: 60 cm

**height:** 135 cm

**Consumable materials:** –

**Accessories:** stool

**Power:** 230V main

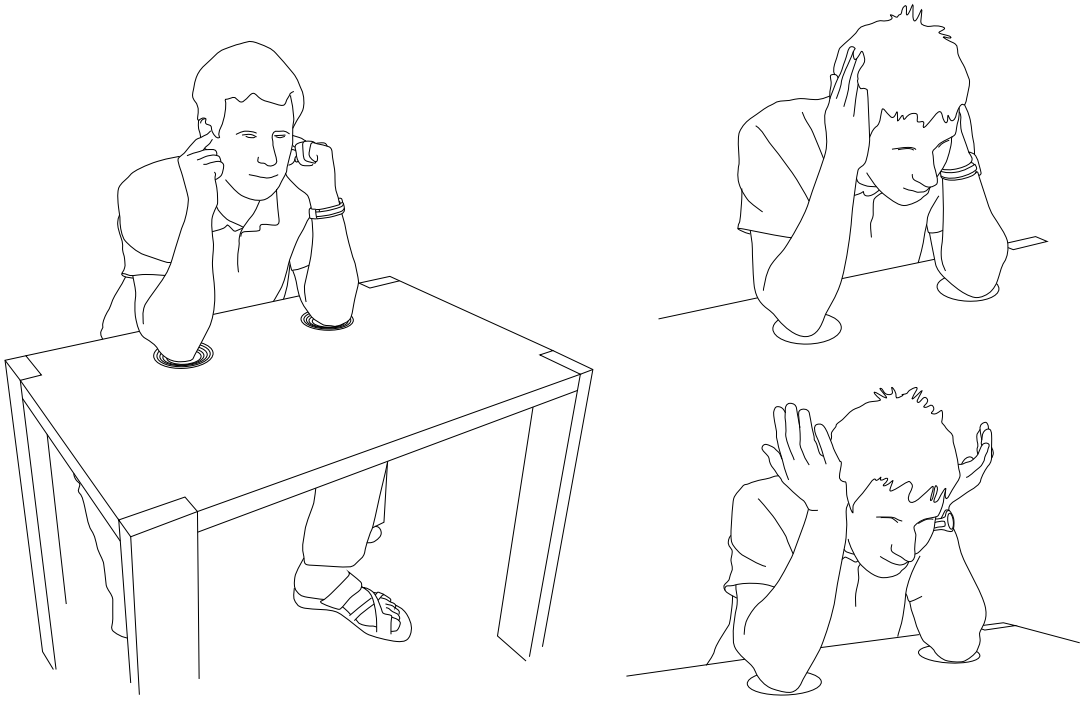
# Vanishing cat

# Bone hearing

## Can sound bypass the eardrum?

This exhibit demonstrates bone conduction. The user sits on a stool and rests their elbows on the circular pads. When they place their index fingers on their ears, they hear music. The user can try placing their wrists or open palms on the ears to see which hand position allows the music to be heard most clearly.

**Keywords:** : sound, mechanical vibration of the medium, amplitude, frequency, sense of hearing, structure of the ear



### Construction of the exhibit

A table with two small circular fields on its top. These fields are mechanically connected to vibration generators that convert electrical signals into vibrations. The vibrators are connected to a music source.

The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 96 cm, depth: 62 cm,

**height:** 73 cm

**Consumable materials:** -

**Accessories:** stool

**Power:** 230V main

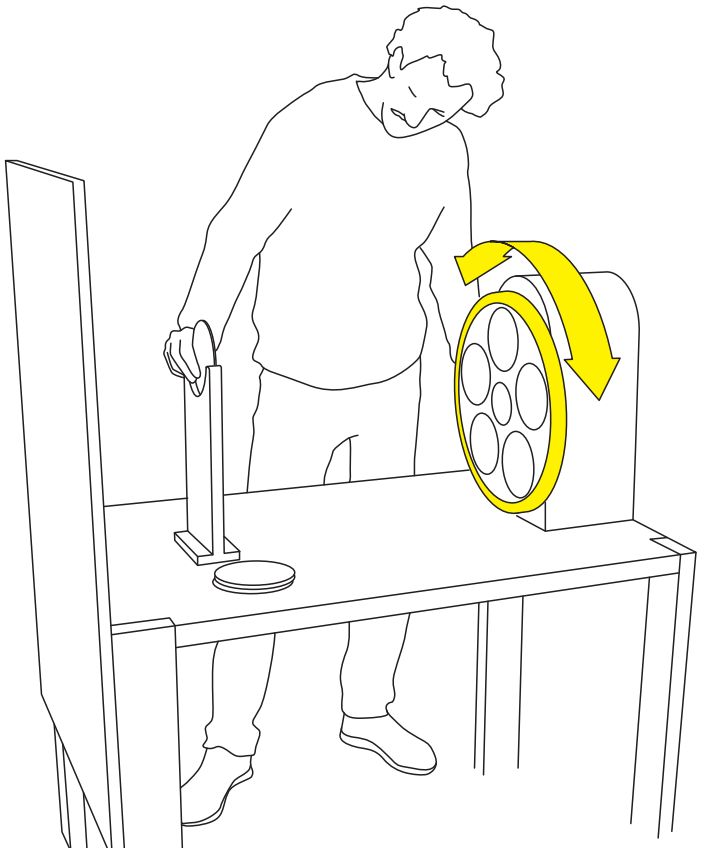
# Bone hearing

# Shapes of light

## Play and learn about light!

The exhibit shows how the shapes of the holes through which light passes affect the image formed on the screen.

**Keywords:** : geometrical optics, aperture, real image, light rays



### Construction of the exhibit

The exhibit consists of a light surface with a rotating disc with holes of various shapes located nearby. At a certain distance from the disc, there is a stand on which discs with holes of various shapes can be placed. At the end of the optical path, there is a white surface (screen).

The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 114 cm, depth: 70 cm

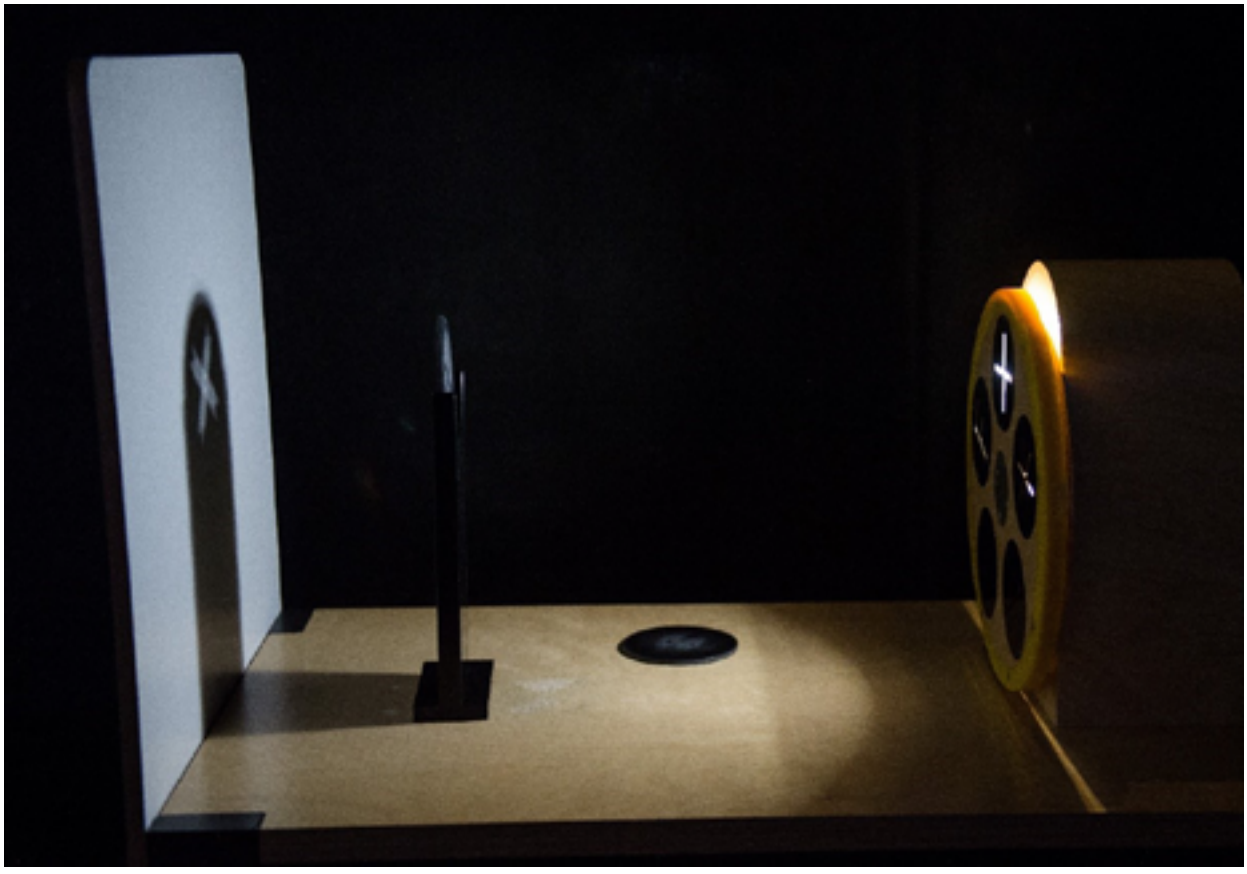
**height:** 146 cm

**Consumable materials:** –

**Accessories:** discs

**Power:** 230V main

# Shapes of light

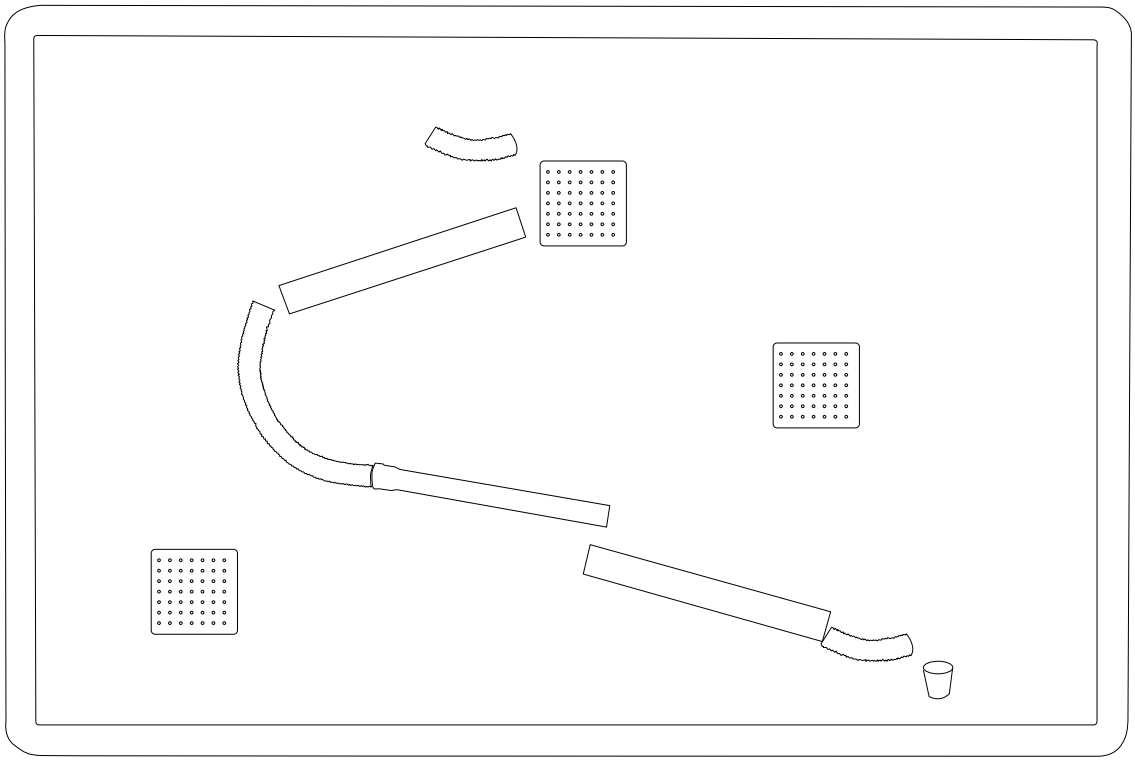


# Great machine

## A simple Goldberg machine and plenty of room for creativity!

The task is to create the most interesting and varied route possible for a small wooden ball on a large metal board. There is no single correct solution, and the more unusual the ideas, the better.

**Keywords:** : Imagination, creativity, gravity, dependencies, domino effect



### Construction of the exhibit

A large metal board and many reusable elements. The exhibit can be used by several people at the same time, which is even recommended due to its size.

### Technical information

**Dimensions:** width: 440 cm, depth: 300 cm,

**height:** 70 cm

**Consumable materials:** various elements needed to create track for the ball, including: magnets, hooks, ropes, rubber bands, plastic pipes, wooden elements, a wooden ball

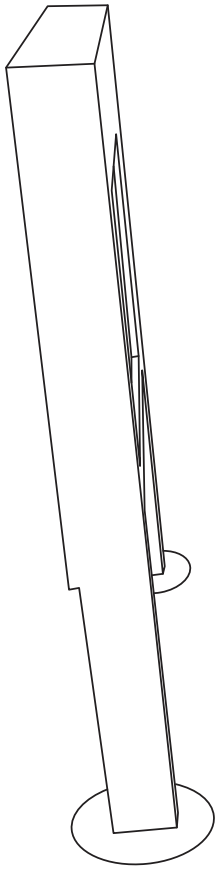
# Great machine

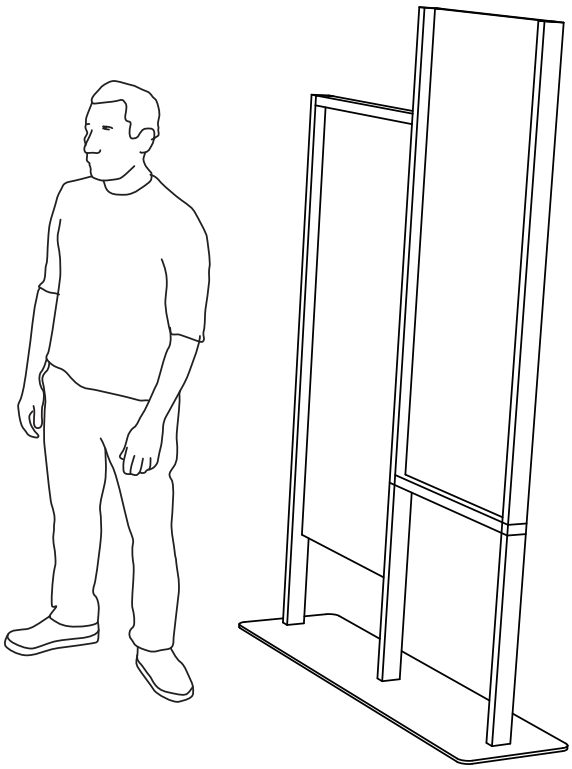
# Thermal imaging camera

## Infrared! See the world through the eyes of a python or viper.

A thermal imaging camera allows you to see the world in infrared — you see the heat emitted by bodies and objects. The screen displays a thermal image in which temperature differences are represented as colour changes — from cool (blue) to warm (red and white).

**Keywords:** : geometrical optics, aperture, real image, light rays





### Construction of the exhibit

A large screen in a wooden frame with a thermal imaging camera placed just above it. In addition, a few metres in front of the screen is a metal stand with two panels. One of them is transparent, made of Plexiglas, and the other is a hanging foil that can be moved. The exhibit allows several people to experiment at the same time.

**Technical information**

**Dimensions:** width: 150 cm, depth: 30 cm,

**height:** 172 cm

**Consumable materials:** -

**Accessories:** two panels (Plexiglas and foil)

**Power:** 230V main

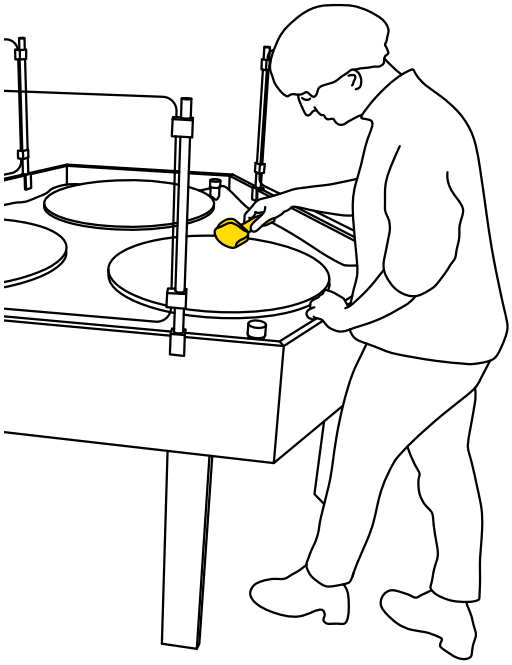
# Thermal imaging camera

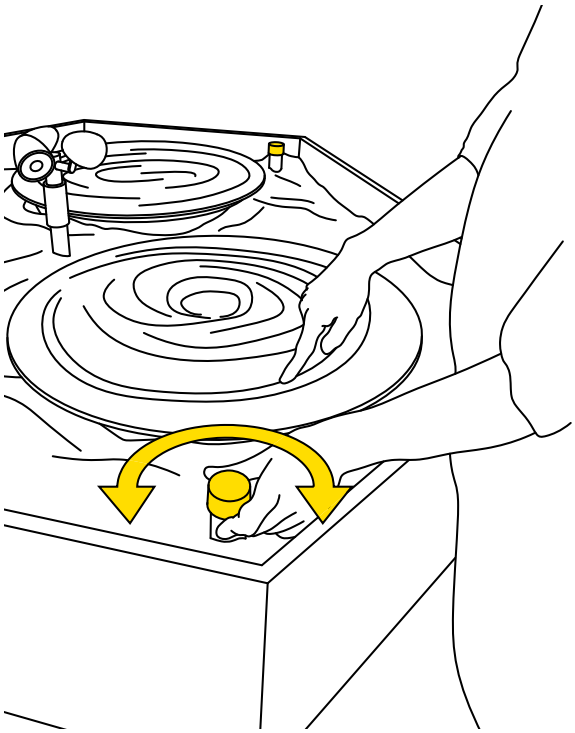
# Drawing in the sand

## Use rotational motion and make a sand masterpiece

With very simple tools or even their own hands, users create amazing patterns on the surface of sand-covered rotating plates. Rotation speed can be adjusted. The exhibit allows not only for great fun, but also for experimenting and creating various shapes, including the Archimedean spiral.

**Keywords:** frame of reference, relativity of motion, art





### Exhibit structure

The exhibit is an irregular hexagon-shaped table with a lot of fine sand on it. The table top's edge is raised to prevent the sand from falling off. On the table top there are three rotating plates propelled by electric engines placed under the table. Next to each plate there is a knob for controlling the rotation speed.

The exhibit allows up to three people to perform experiments simultaneously.

### Technical details

**Measurements:** table: 150 × 150 cm; plate: ⌀ 60 cm

**Consumables:** sand

**Accessories:** shovels, slats, and rods for the users to moving sand, gouging in it and performing other experiments

**Power:** 230V power supply

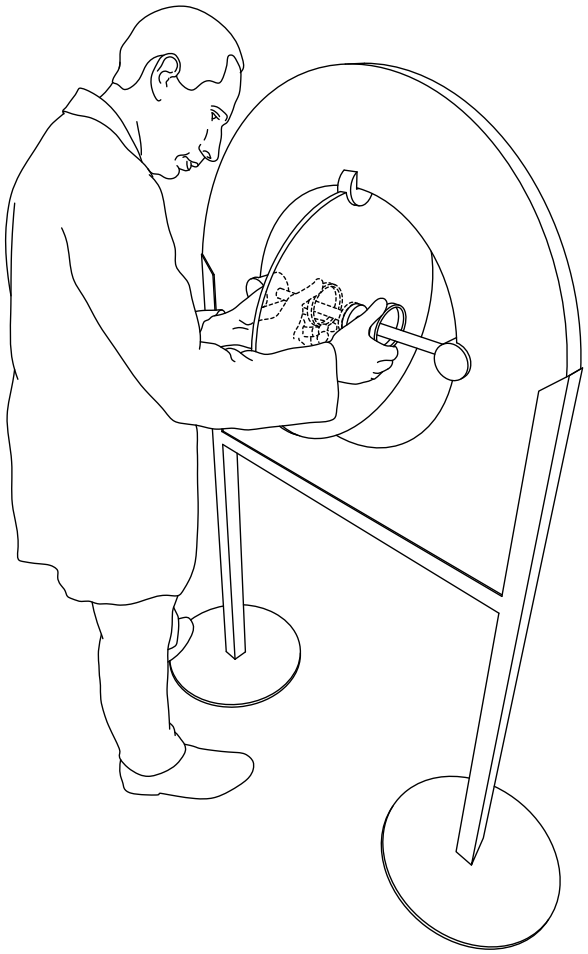
# Drawing in the sand

# Mirror window

## What happens when the brain receives contradictory information?

Due to the specific position of the mirror, what the experimentator sees is dissonant with what the muscles in their body feel. Very often human brain wrongly interprets images received by the sense of sight. It is so, because sight is the dominant sense.

**Keywords:** mirrors, reflection, perception, optical illusions



### Exhibit structure

The exhibit comprises of a vertically placed board with a round mirror installed across it, together with two brass rings that can be moved easily to the sides. The whole structure is joined with durable fittings that make the exhibit reliable and safe.

The exhibit can be used by one person simultaneously.

### Technical details

**Measurements:** 115 × 45 cm

**Consumables:** –

**Accessories:** –

**Power:** –

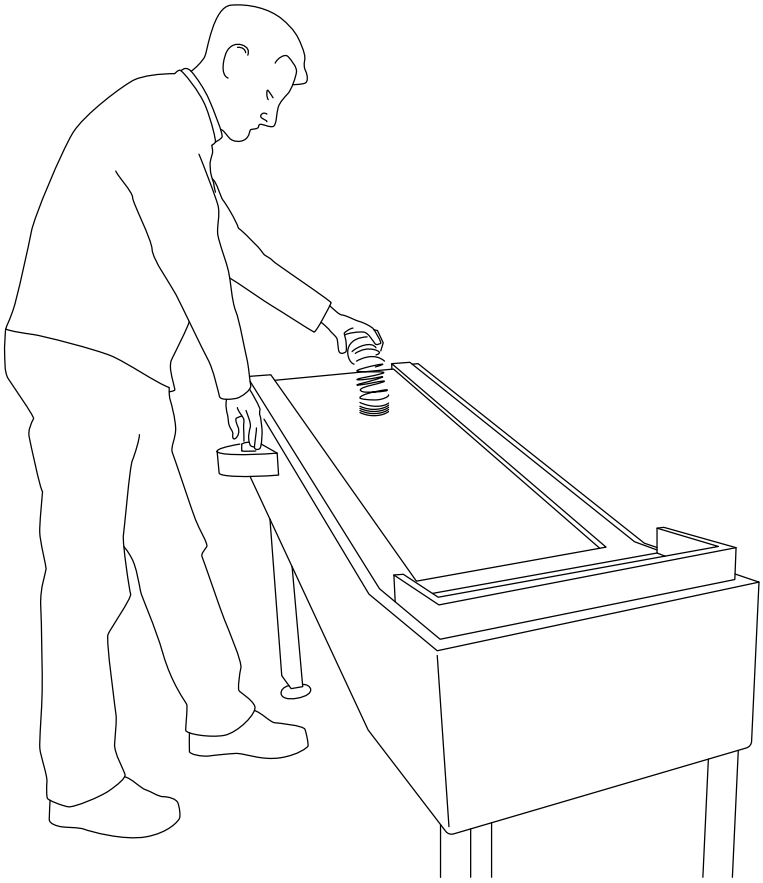
# Mirror window

# Walking spring

## Take the spring... for a walk and learn that science doesn't have to be dead serious!

The experimentator's task is to make the spring "walk" on the conveyor belt. When one end of slinky falls on the belt, its parts stretch. Then the spring's elasticity makes its coils shrink, and then re-form itself. This makes the spring move in wave motion, flow and gain momentum. As a result, the other end of the spring lands further, makes another "step" and the process continues. The user can turn the knob to set the belt's speed at such pace that the spring will be "walking" without actually moving forward.

**Keywords:** kinetic energy, potential energy, elasticity, gravitational pull



### Exhibit structure

The exhibit comprises an inclined plane with a conveyor belt. Its speed can be controlled and adjusted with a knob. At the top and bottom of the belt, there are shelves secured with raised edges. Users' safety is guaranteed by the optical barrier installed at the end of the conveyor belt.

The exhibit can be used by one person at a time.

### Technical details

**Measurements:** 150 × 55 cm

**Consumables:** –

**Accessories:** Slinky spring

**Power:** 230V power supply

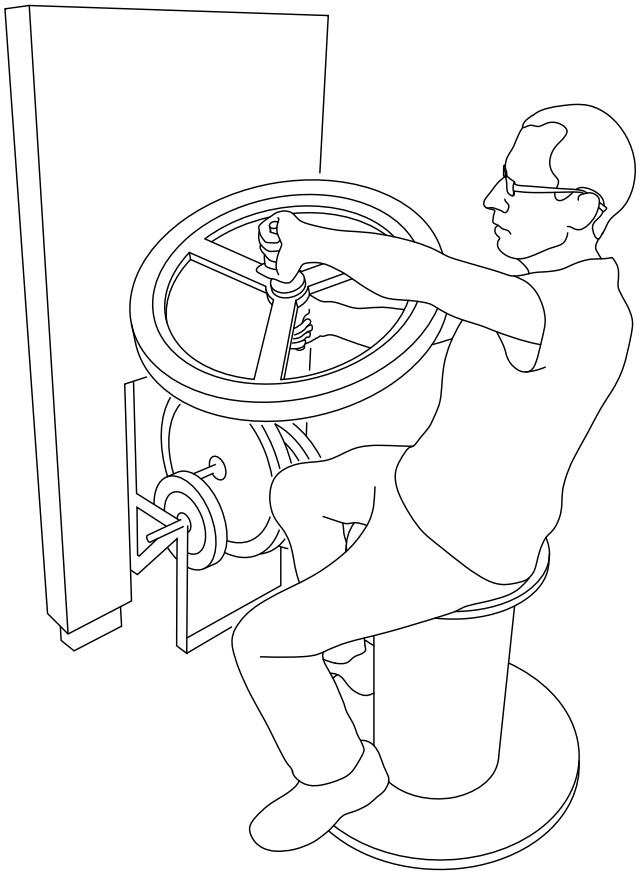
# Walking spring

# Bicycle twists

## Add a rotating stool to the gyroscope, and let the fun begin!

This uncomplicated exhibit illustrates the gyroscopic effect phenomenon and the law of conservation of angular momentum. When the user tries to move the rotating wheel they are holding in their hands, they can feel the force impeding the change of position of the rotation axis (defined by wheel handles). The user and the rotating stool constitute a one single whole. Any attempt to change the axis of the rotating when impacts the rotating movement of the whole exhibit.

**Keywords:** dynamics, circular motion, moment of inertia, gyroscopic effect



### Exhibit structure

There are two main parts of the exhibit: a rotating stool and a stand with wheel handles. Each user can choose one of three different-sized wheels (depending on the user's height and arm length). The wheels have suitable bearings and are weighted down on the perimeter. Supporting frames of the stool and the board are made from steel profiles.

The exhibit can be used by one person at a time.

### Technical details

**Measurements:** boards: 90 × 50 cm; stool: ø 60 cm

**Consumables:** –

**Accessories:** –

**Power:** –

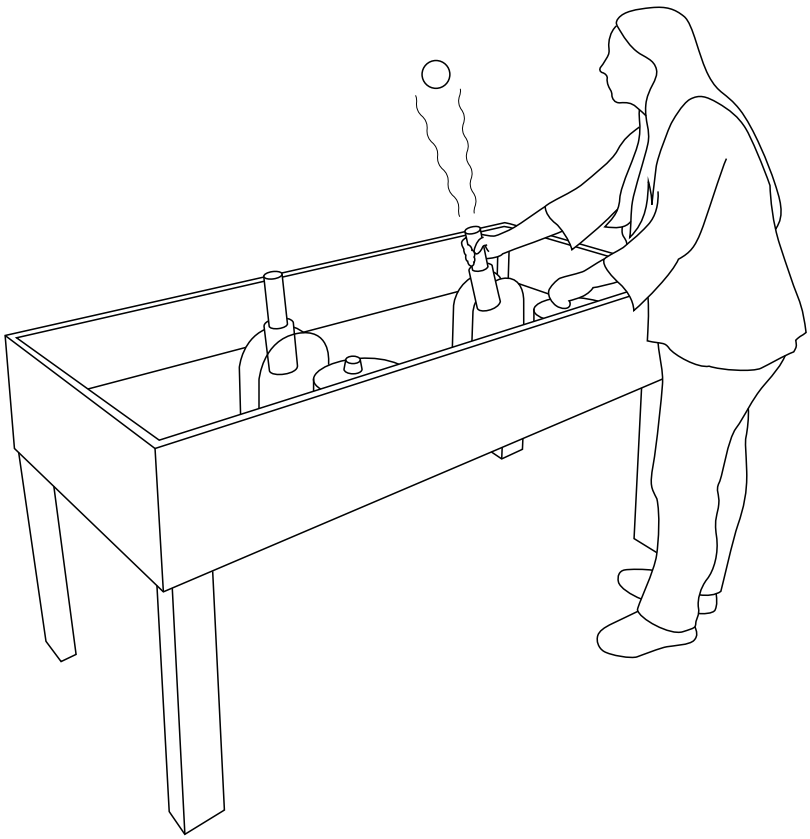
# Bicycle twists

# Hanging balls

## Ready for an arcade game? Steer the ball without touching it!

The experimentator places one ball at the exit of the tube and releases air flow by turning the knob. The ball stays within the air stream even when the tube is inclined from the vertical. The exhibit presents the Coandă effect, which is a physical phenomenon reflecting the tendency of a jet of fluid to stay attached to a convex surface.

**Keywords:** aerodynamics, Coandă effect



### Exhibit structure

The exhibit comprises of a table with highly raised edges, on which you will find two air jet tubes and two control knobs. The whole structure is finished off with a frame, on which a safety net has been placed in order to secure all elements from falling out.

The exhibit can be used by one person simultaneously.

### Technical details

**Measurements:** 170 × 60 cm, height: 220 cm

**Consumables:** –

**Accessories:** plastic balls and or marble balls

**Power:** 230V power supply

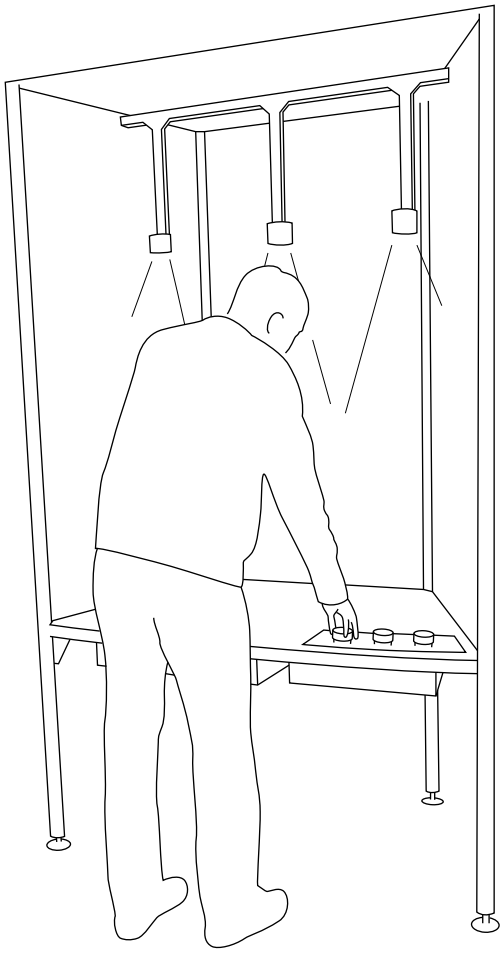
# Hanging balls

# Colourful shadows

## You think a shadow is always dark? It's time to find out!

The exhibit allows the experimentator to observe the process of mixing of light colours in the RGB system. Above the table there are lamps giving red green and blue light. With lamps being installed slightly apart and the possibility of adjusting light intensity, the user can observe colourful shadows on the counter. Shadow is the area with less light received. Covering one colour with your hand makes less light of this colour reach the counter, which allows for other colours to mix together. This way the user can influence colour creation.

**Keywords:** light, mixing of colours, RGB, CMY



### Exhibit structure

The exhibit is a darkroom-like cabin with a light counter on which you can look at various colourful shadows. The light comes from three powerful diodes in RGB colours. Desktop installed on the counter allows for adjusting light intensity separately for each colour.

The exhibit can be used by a couple of persons simultaneously.

### Technical details

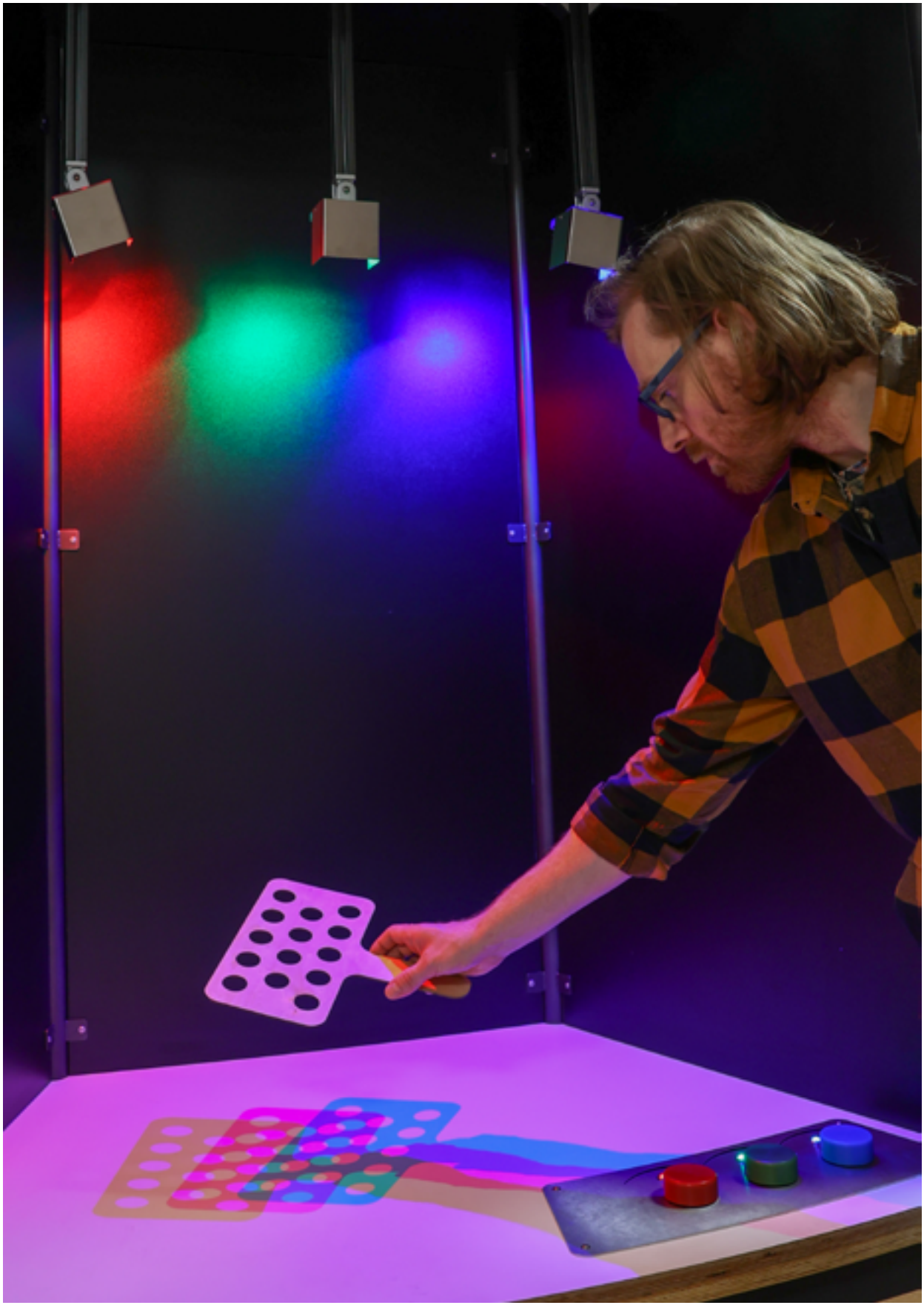
**Measurements:** 140 × 180 cm; height: 235 cm

**Consumables:** –

**Accessories:** shapes for creating shadows and colourful blocks

**Power:** 230V power supply

# Colourful shadows

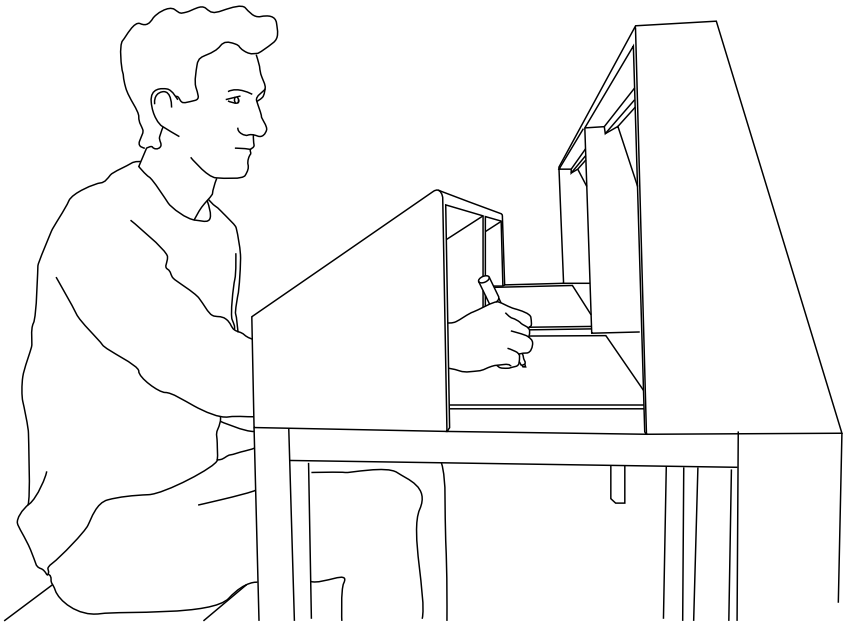


# Mirror drawing

Copy a simple shape seen in the mirror. When you see both the shape and your hands only in the reflection, this simple task turns out to be really difficult!

The user's task is to outline the contour of a simple geometric shape with a felt-tip marker, looking only at its reflection in the mirror. However, there is one thing that makes this task difficult – the user can only see their hands in the mirror. When they move their hand forward, the mirror image of the hand moves backwards; when they move their hand backwards, the mirror image moves forward. This makes correctly moving the hand holding the marker a really complicated task.

**Keywords:** hand-eye coordination, mirror image



## Construction of the exhibit

The exhibit consists of a long table with a cover concealing the user's hands and the drawing zone affixed to it. Drawings of geometric figures are placed on the table top under a glass pane, and thanks to LED lighting, they are perfectly visible in the mirror mounted above. The user draws them directly on the glass pane using a dry-erase felt-tip marker. The supply of markers and felt eraser pads are located within easy reach of the user.
The stand also includes 3 stools, which can be easily moved to enable access for wheelchair users.

The exhibit allows three people to carry out the experiment simultaneously.

## Technical information

**Dimensions:** width: 224 cm, depth: 60 cm, height: 117 cm

**Consumable materials:** felt-tip dry-erase markers and erasers for dry-erase boards

**Accessories:** three stools

**Power supply:** 230V mains

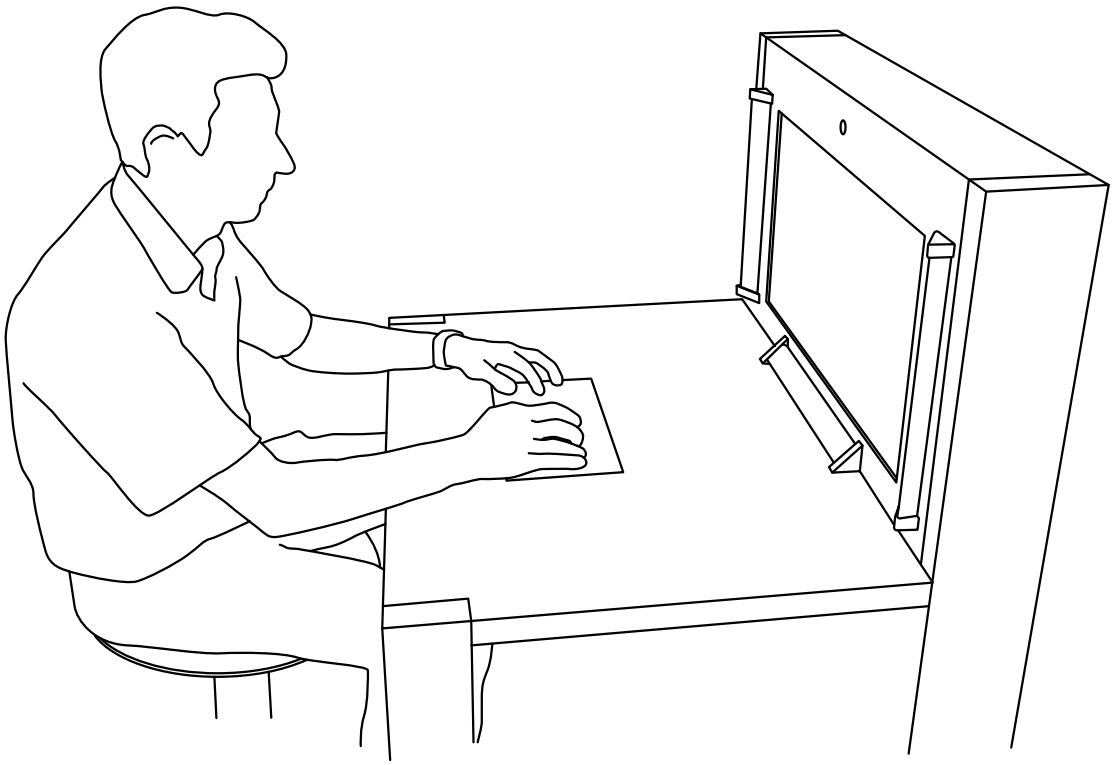
# Mirror drawing

# Two left sides

## See what you would look like with a perfectly symmetrical face

The user sits down on the chair in front of a dashboard, that allows them to take a portrait photograph on the built-in screen. Then, as a result of electronic image processing, they can see the picture made up of two left or two right halves of their face. It turns out that while harmonious proportions result in the perception of a person as attractive, perfectly symmetrical faces usually look disturbing and unnatural.

**Keywords:** reflection symmetry, bitmap, electronic image processing



### Construction of the exhibit

The exhibit is based on the table, with a control panel placed on the table top and a vertical board with a high-resolution screen and lighting for taking clear pictures of the user's face in the middle of the table. Above the screen, in a common housing, there is also a digital camera, which outputs its preview directly on the screen.

The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 90 cm, depth: 80 cm, height: 125 cm

**Consumable materials:** none

**Accessories:** stool

**Power supply:** 230V mains

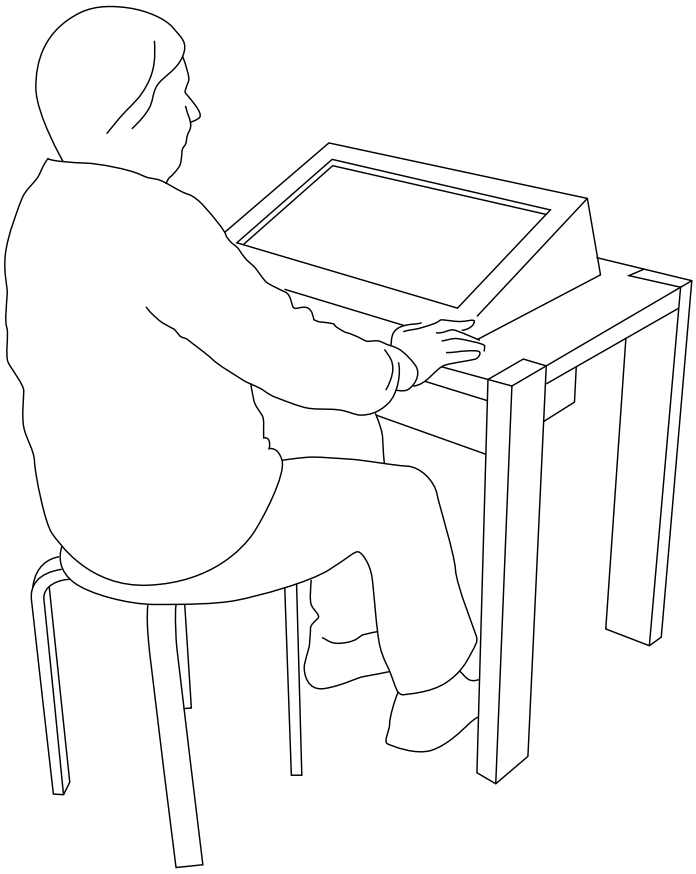
# Two left sides

# Masters of instant memorisation

## When you need to remember something right away, chimpanzees do better than people!

The exhibit recreates an authentic scientific experiment that studied ultra-short-term memory.
The user can briefly see digits scattered around in random places on the screen. After a moment, the digits turn into rectangles. The task is to identify the rectangles, in the order corresponding to the ascending order of numbers. The experiment has proven that when it comes to remembering something right away, chimpanzees do better than people! This exhibit allows you to experience this for yourself.

Keywords: types of memory, ultra-short-term memory, experiment, cognitive psychology.



### Construction of the exhibit

The stand is a simple table with an inclined desktop, equipped with a 21-inch touch screen.
The touch screen is a uniform interface for communication with the user.

The exhibit can be used by one person at a time.

### Technical information

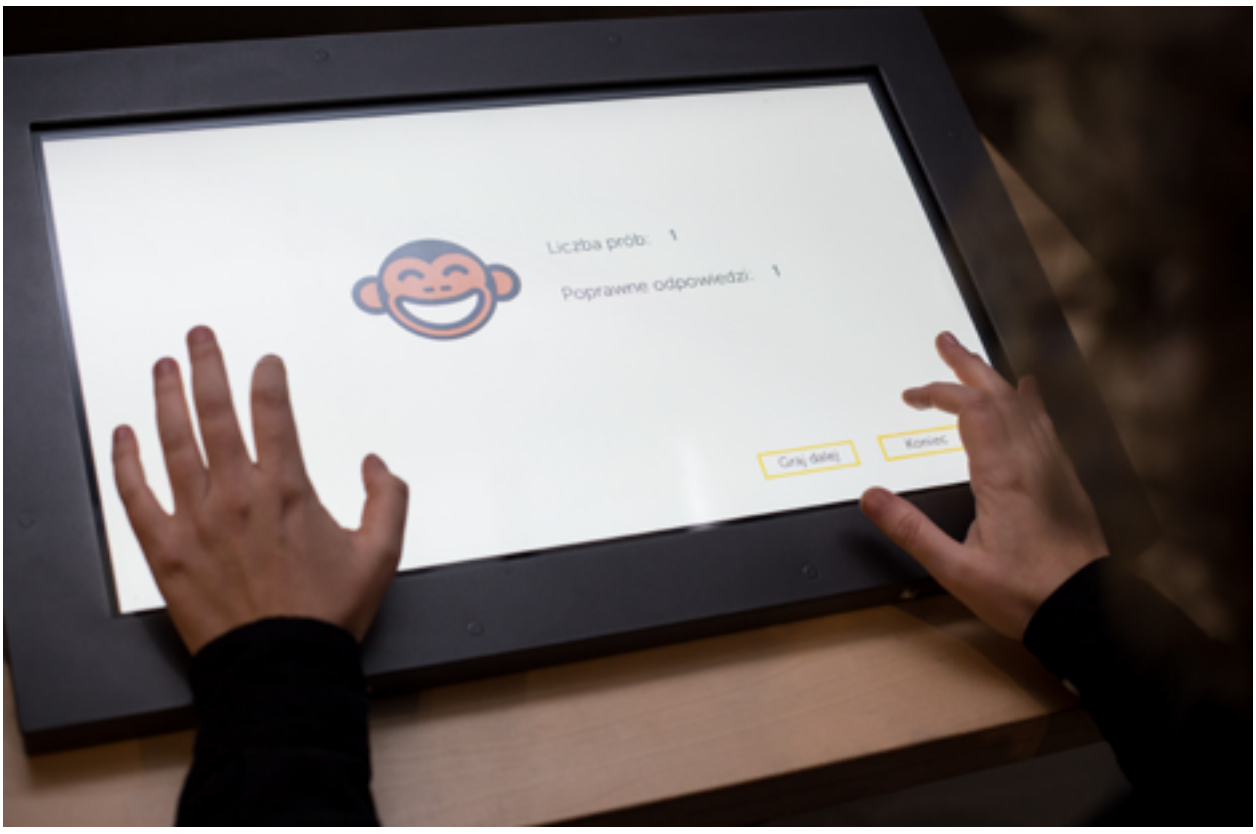
**Dimensions:** width: 85 cm, depth: 56 cm, height: 76 cm

**Consumable materials:** none

**Accessories:** stool

**Power supply:** 230V mains

# Masters of instant memorisation

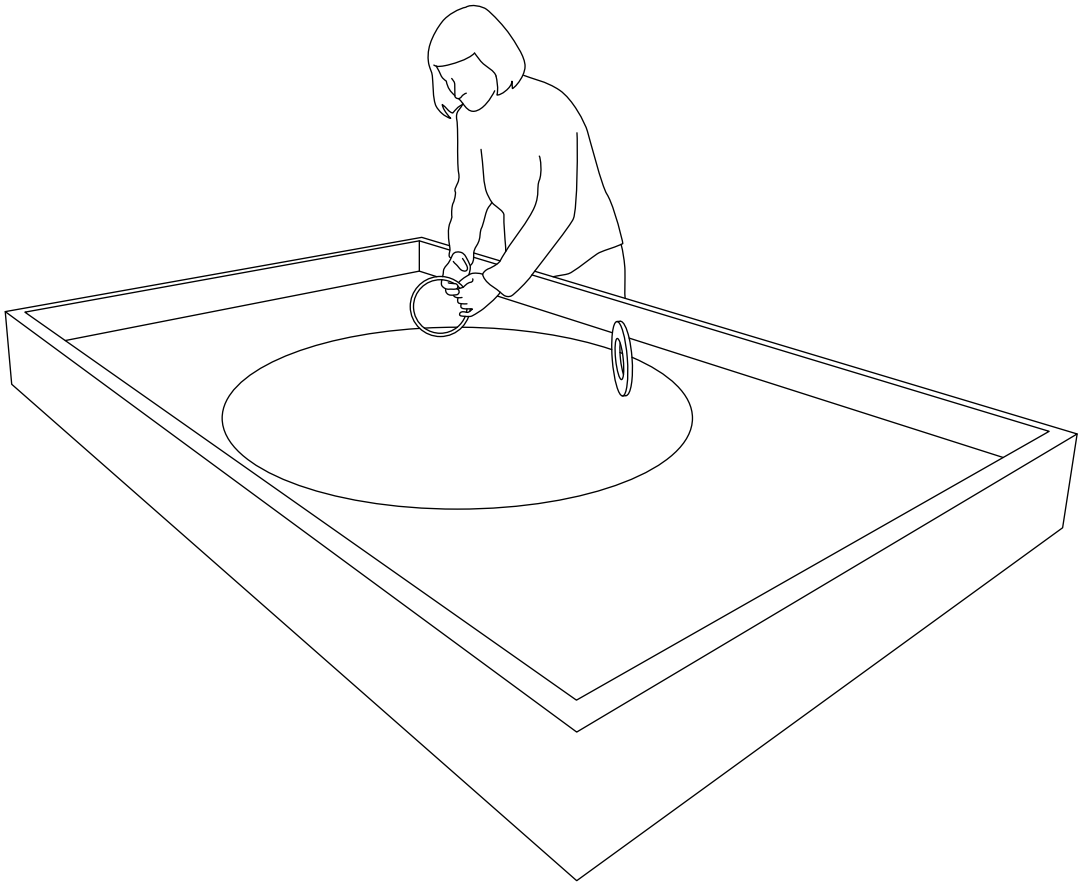


# Rotating Table

## What if we turned the classical mechanics up a notch...?

The task in the experiment is to arrange the balls, rings and discs in such a way that they maintain balance and roll on a constantly rotating plate. The path of a rolling object depends on its position and angle after starting. Users look for original configurations of objects and spend a lot of time playing with this exhibit.

**Keywords:** classical mechanics, friction, momentum, gravity, balance



### Construction of the exhibit

The exhibit has the form of a large table under which a mechanism driving a circular flat plate was installed. The disc rotates at a steady rate of about 75 revolutions per minute. On the table top, there is a number of objects used to perform experiments (rings, discs, balls). Maintenance access to the drive is available underneath the table top.

The exhibit allows anywhere from several up to approximately a dozen people to experiment simultaneously.

### Technical information

**Dimensions:** table: 205 × 130 cm; plate: ⌀ 100 cm

**Consumable materials:** –

**Accessories:** rings, discs, balls; optional: platform for persons of lower height

**Power supply:** 230V mains

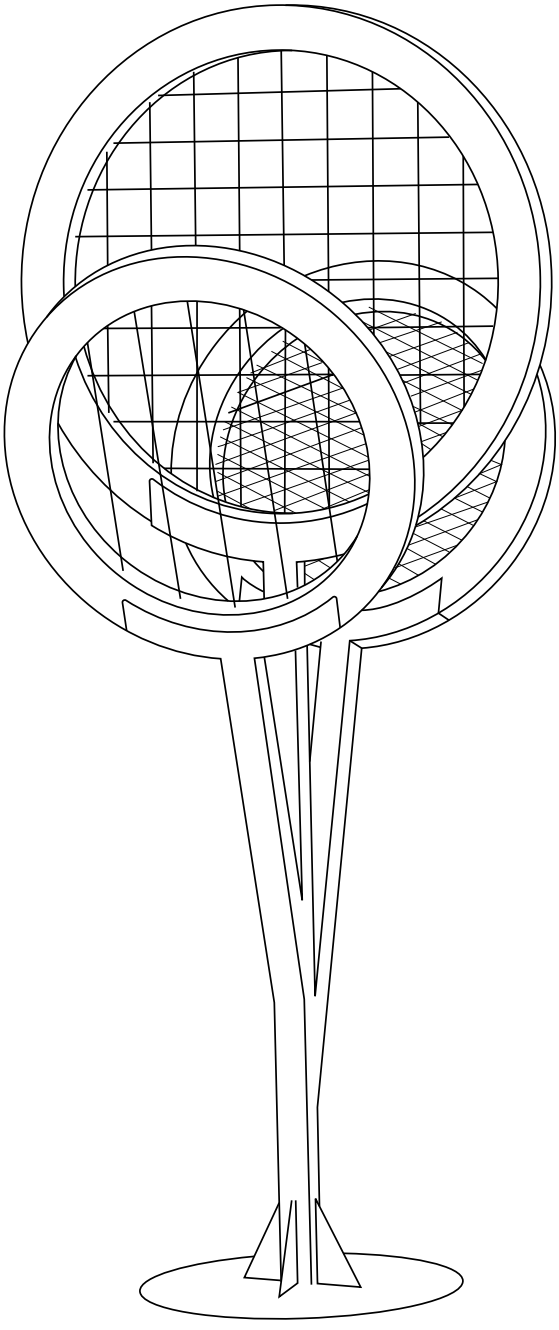
# Rotating Table

# Velvet hands

## Drag your hands along the metal mesh and feel the illusion of pleasant smoothness.

The user's task is to drag their closed hands along metal meshes. In this experiment, the user feels the illusion of 'velvety hands', while touching one of the meshes, making them believe that they are touching a very soft and smooth fabric. We don't know exactly why this tactile illusion happens. Since we are all different, some users may perceive stimuli differently. Some people don't feel anything special at first. Others need to close their eyes in order to feel the effect.

**Keywords:** sense of touch, perception, illusions



### Exhibit structure

The exhibit has the form of a stand. It comprises three metal meshes stretched over wooden rims.

The exhibit allows three people to experiment simultaneously.

### Technical details

**Measurements:** 70 × 60 × 140 cm

**Consumables:** –

**Accessories:** –

**Power:** –

# Velvet hands

# Rotating mirrors

## Some mirrors can put the world on its head!

The exhibit consists of six sets of mirrors. Each set consists of a pair of mirrors forming a certain angle. When rotating a set of mirrors, the user notices that the image in the mirror is turned upside down, while in other cases it remains natural. Depending on whether an even or odd number of reflections occurred, the image will be reversed or not.

**Keywords:** geometric optics, directional reflection, multiple reflections

### Exhibit structure

The exhibit is built on the basis of a triangle. The plywood construction is set on metal legs. Two sets of mirrors with different opening angles between the panes are attached to each of the three sides. Each set is mounted on a rotating base with handles.

The exhibit can be used by six people at a time.

### Technical details

**Measurements:** 170 × 150 × 120 cm

**Consumables:** –

**Accessories:** –

**Power:** –

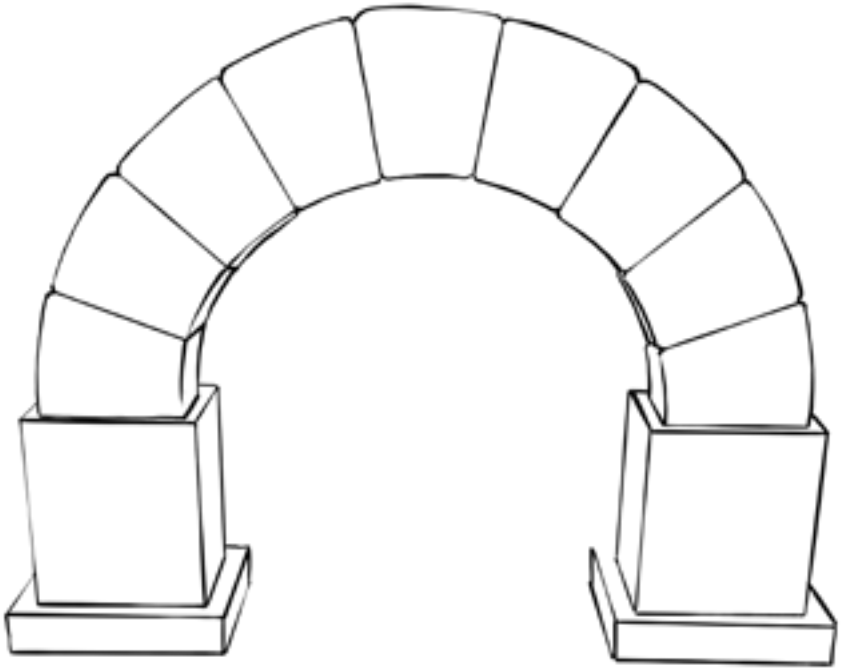
# Rotating mirrors

# Build an arch

## An arch - ornament or structural element?

The user's task is to build the arch by arranging the foam bricks to achieve a stable structure. The exhibit can be used individually and in teams (which promotes cooperation and exchange of ideas). Once the arch is built, the user tests its strength by pressing on the structure from above or from the side to observe its resistance to different loads.

**Keywords:** architecture, construction, arch



### Construction of the exhibit

The exhibit consists of two columns and nine foam blocks. On the top surface of each column there is a hollow into which one of the bricks can be inserted. The bricks form a semi-circular arch when placed correctly.

The exhibit can be used by a couple of persons simultaneously.

### Technical information

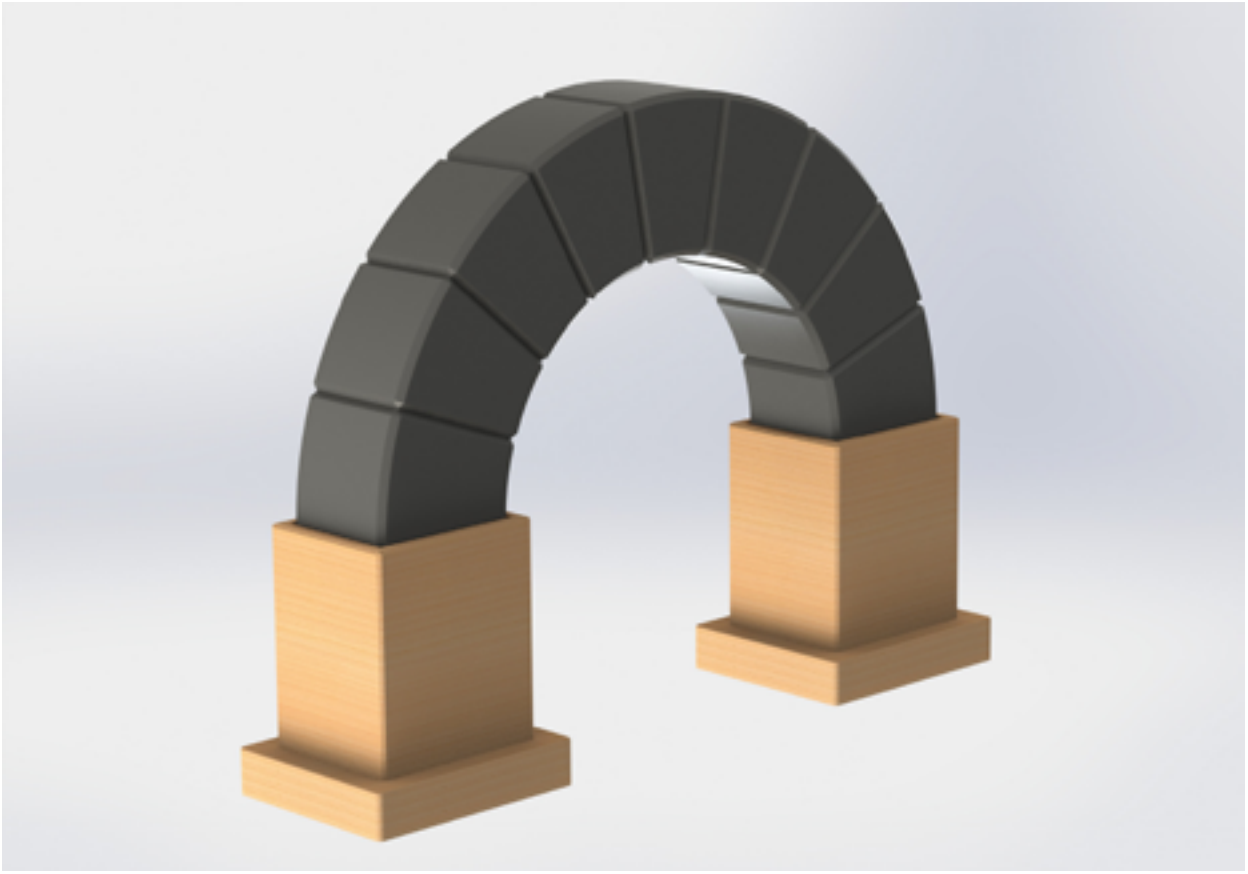
**Dimensions:** width: 131 cm, depth: 32 cm, height: 100 cm

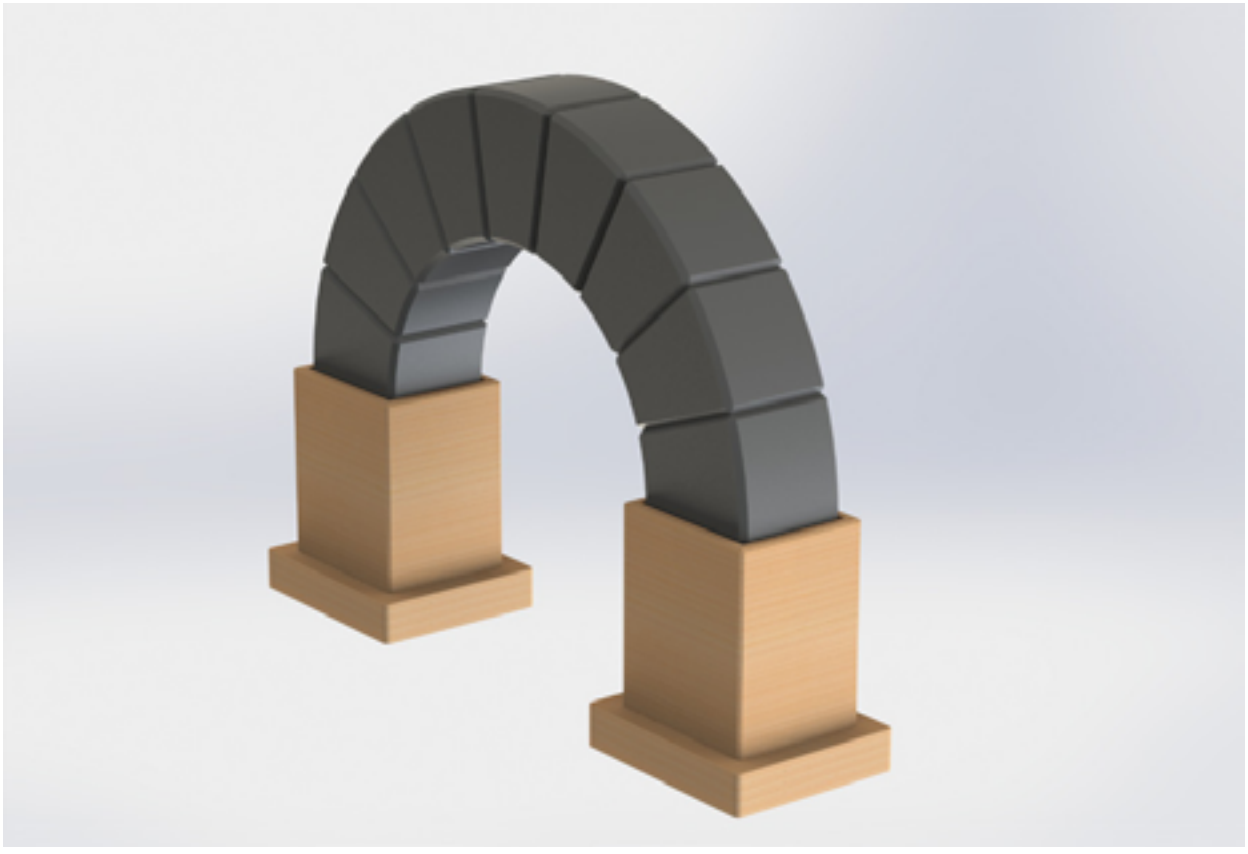
**Consumable materials:** none

**Accessories:** none

**Power supply:** none

# Build an arch





# Propeller

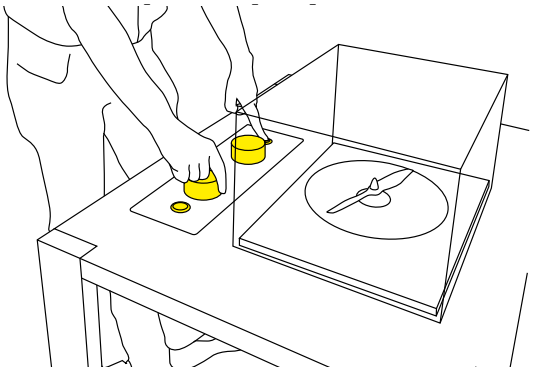
## Through the use of strobe light, we can succumb to the illusion.

The user can experiment by changing the type of lighting between continuous and strobe light, and by adjusting the propeller speed and flash frequency. In continuous light, the propeller can hardly be seen, its edges are blurred. In stroboscopic light, on the other hand, the image of the propeller is clearer, albeit flickering, and its movement is difficult to recognize because the flashes of light show only the propeller's momentary positions.

Changing the frequency of the flashes produces different effects. Depending on the settings, it can appear to us that the propeller is stationary, moving in slow motion or even backwards! The 'freeze' effect occurs when the flash frequency is perfectly matched to the speed of the propeller.
These experiments show how the difference between the frequency of light and the speed of the propeller affects the perception of motion.

The illusion experienced when looking at a propeller in pulsating light is called the stroboscopic effect. It is not only due to the temporal alignment of the light flashes with the rotation of the propeller, but also to the way our brain works to interpret visual stimuli. The impression that the propeller remains stationary occurs when the frequency of the flashes and the speed of rotation are properly synchronised. A sequence of almost identical images of the propeller, arising at moments of flashing, is interpreted by the brain as a view of the propeller at rest.

**Keywords:** stroboscopic effect, illusion of motion, brain interpretation, optical illusions, lightKeywords: stroboscopic effect, illusion of motion, brain interpretation, optical illusions, light



### Construction of the exhibit

The exhibit is a table with a transparent cover set on the tabletop. Under the cover is a yellow biplane propeller mounted on a vertical axis, driven by a motor hidden under the tabletop.
An LED lamp is mounted on the top wall of the cowl, its light directed at the propeller.
On the control panel, located in front of the cowl, there are: buttons to select the type of light: 'STROBOSKOP' or 'CONTINUOUS LIGHT', knobs to adjust the propeller speed and the frequency of light flashes. The display on the dashboard shows both values.

The exhibit can be used by one person at a time.

### Technical information

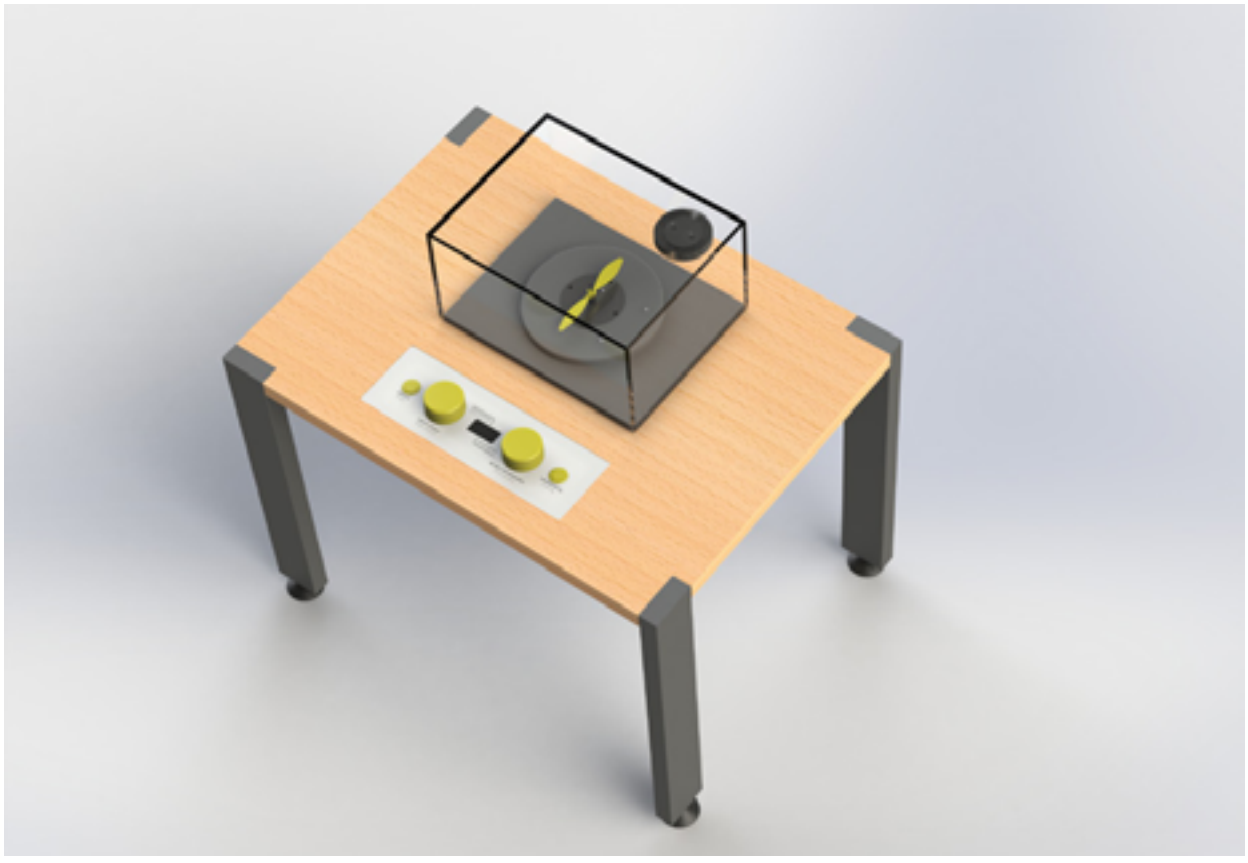
Dimensions: width: 100 cm, depth: 75 cm, height: 101 cm

Consumable materials: none

Accessories: none

Power supply: 230V

# Propeller



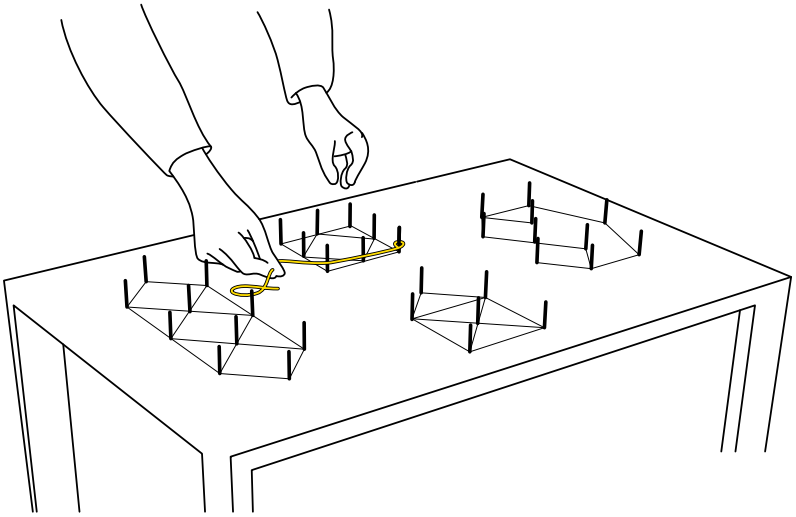
# String-graphs

## By representing some problems with graphs, we can find their most optimal solutions.

Using the string, reproduce the given graph pattern. You cannot go through the same section twice. The starting point in each graph is variable and its location determines whether the task can be completed or not.

Graph theory, on which this task is based, is used in many fields, including mathematics, logistics, programming or social network analysis. A graph is defined as a set of vertices that are connected by segments. Each segment ends and begins at some vertex. It is a mathematical structure used to represent and study relationships between objects. Graphs are used, among other things, to optimise, or streamline, processes. By representing some problems with graphs, we can easily find solutions to them, e.g. optimise navigation by determining the shortest path between the starting point and the destination.

**Keywords:** graph, graph theory



### Construction of the exhibit

There are four graph boards on the tabletop. Each graph is a collection of vertices (metal pins) connected by lines. A string is attached to one of the pins. The end of the string lies loose on the tabletop and can be attached to any mandrel.

The exhibit can be used by a couple of persons simultaneously.

### Technical information

**Dimensions:** width: 100 cm, depth: 75 cm, height: 101 cm

**Consumable materials:** none

**Accessories:** none

**Power supply:** na

# String-graphs

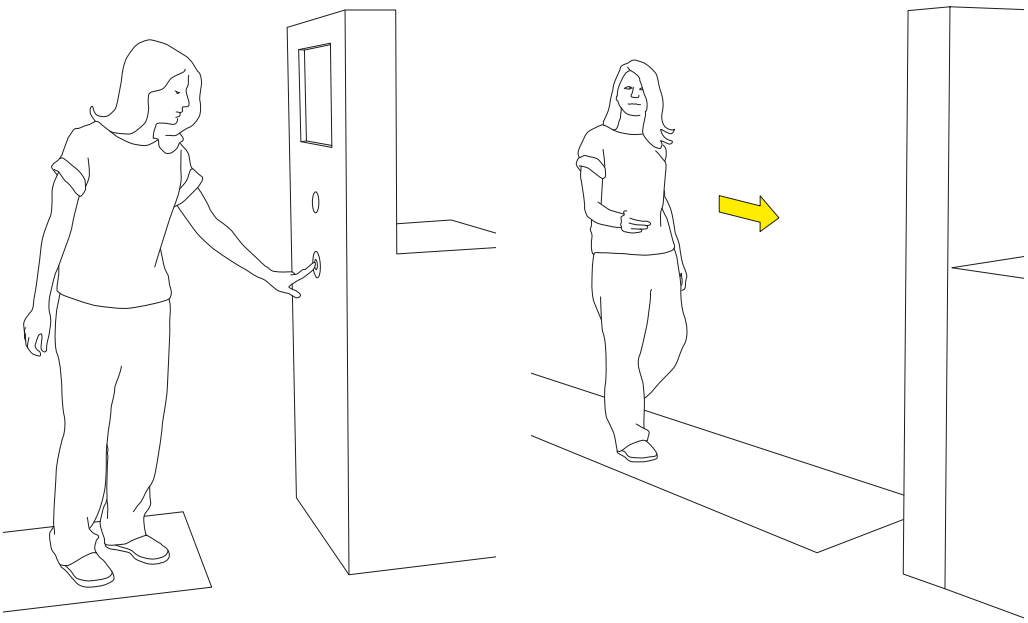
# World line

## Will you be able to recreate tthe graph while moving?

The user is challenged to reproduce the white function graph displayed on the monitor by moving forward or backward, faster or slower along the track. Each of his movements is recorded by the ultrasonic echolocation system and represented on the screen as a red graph. The challenge is to match the red graph with the white graph. This interactive experience allows you to observe and control your 'world line', as physicists describe the movement of a body in time and space.

An experimenter's world line is a record of their movement over time. It reflects how fast they are moving and when they are accelerating, decelerating, or changing direction. World lines never turn back; even if an object is moving backward in space, it is always moving forward in time. This exhibit allows you not only to understand the basic principles of physics but also to see your own movement from a unique perspective—as an irreversible sequence of events.

**Keywords:** world line, position, passage of time, graph of a function, space-time



### Construction of the exhibit

The exhibit consists of a several-meter-long straight track along which the user walks. At one end of the track is a computer screen displaying function graphs. An ultrasonic echolocation system records the user's movement in real-time. The exhibit is designed for one person and allows for individual experience and learning through interaction.

The exhibit can be used by one person at a time.

### Technical information

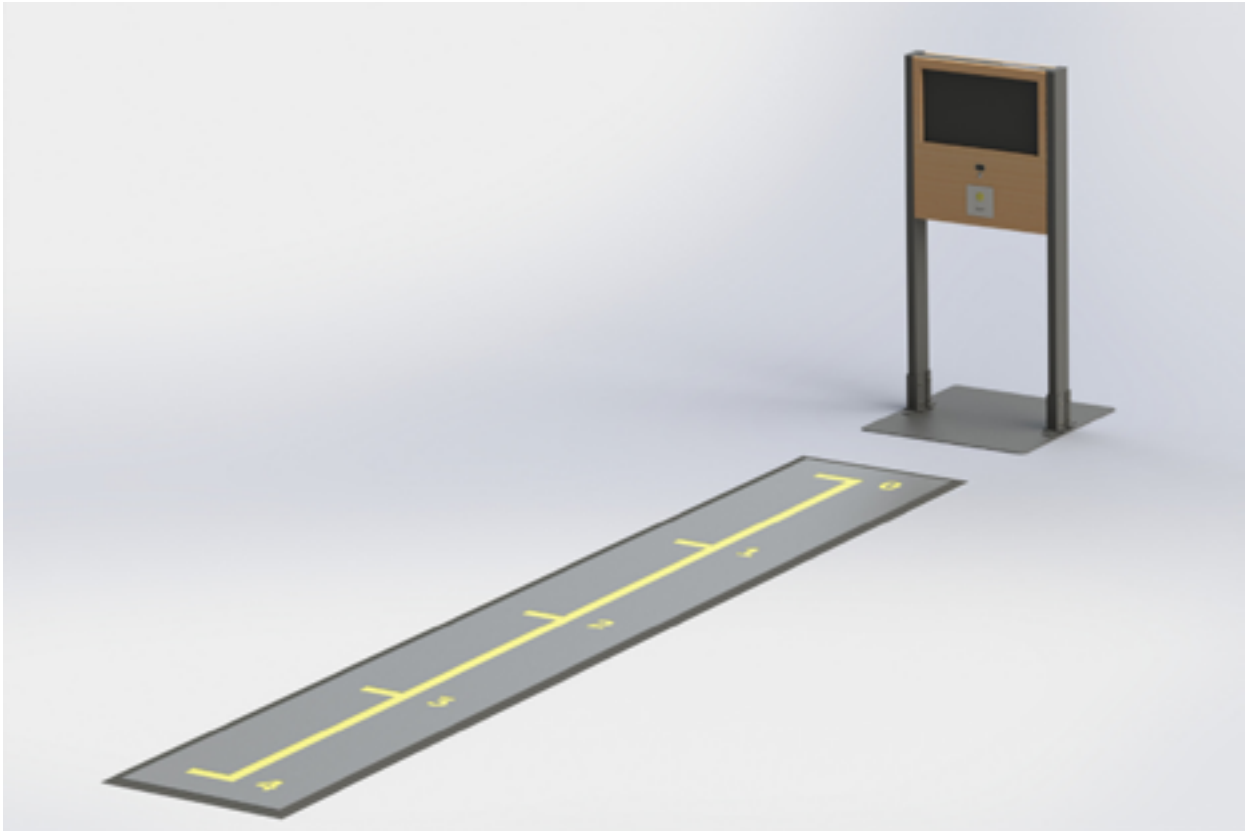
**Dimensions:** 1. monitor stand: width: 75 cm, depth: 75 cm, height: 145 cm, 2. carpet: width 75 cm, depth 400 cm

**Consumable materials:** none

**Accessories:** none

**Power supply:** 230V

# World line



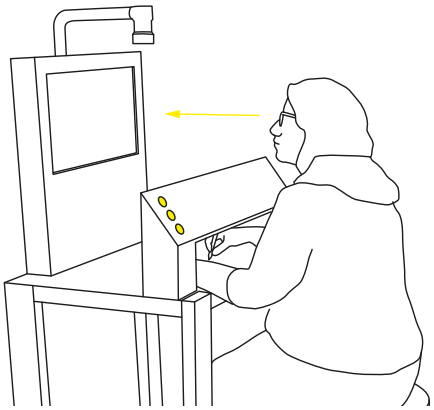
# Delayed drawing

## When the information coming from sight is different from what the muscles in your body are feeling - the brain starts to get lost.

The user's task is to draw a violin key on the glass, along the line of the drawing below the glass. This is a simple task if we can directly see the drawing, the glass and our own hand with the marker. However, if we can see the actions on the monitor screen, it is only in the version with a delay time of '0' that drawing is not a challenge. In the other two versions, the image on the screen appears with a 1- or 2-second delay. This means that the user sees something other than what he or she 'feels', because he or she is making a hand movement 'by heart' and the eyes see the result with a delay.

The exhibit provides an opportunity to see how we act when the signal from the two senses is inconsistent, disagreeing with our previous experience. In the case of 'Drawing with Delay', one of the senses is vision and the other is deep sensation (known as 'proprioception'), which is the awareness of the position of one's body parts without looking at them. Throughout life, we learn to coordinate our movements according to the stimuli we receive from the environment, including those from sight. Thus, when we want to eat, we are able to precisely and unerringly reach for a spoon, scoop up the soup with it and bring it to our mouth. In the exhibit, the rules that our body has learned are altered. As a result, the brain - according to the experience it has gained before - reacts to what it sees and performs the task incorrectly.

**Keywords:** vision, proprioception, perception, drawing, coordination



### Construction of the exhibit

The exhibit consists of a table with a chair. On the tabletop is a drawing of a violin key covered with glass. A slat is mounted above it, obscuring the drawing for the user. Thanks to a camera mounted above the tabletop, the image of the key can be seen on a monitor screen. The control panel can be used to select the time – 0, 1 or 2 seconds – by which the image shown on the monitor is delayed. The user is provided with a dry erase marker and a wiping sponge.

The exhibit can be used by one person at a time.

### Technical information

**Dimensions:** width: 80 cm, depth: 60 cm, height: 153 cm

**Consumable materials:** none

**Accessories:** none

**Power supply:** 230V

# Delayed drawing

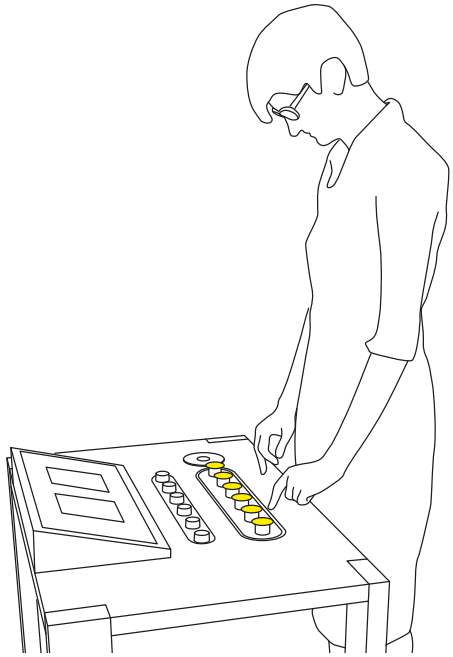
# Memory test

## Test your short-term memory!

The user's task is to check their memory. When the 'START' button is pressed, the lights light up in sequence. The user has to remember the sequence of flashes (which button lights up after which) and repeat it by pressing the corresponding lamps. The displayed sequence extends by one flash each time - this continues until the user makes a mistake in the sequence of pressing the buttons.
The user can compare his/her own result (number of flashes stored) displayed on the panel with the best result obtained that day (since the exhibit was started).

Everyone has different abilities, including memory. We owe our ability to remember the order of the flashes that light up to our memory, which on a daily basis allows us to orient ourselves to what has just happened. According to the classical storage theory, this is called short-term memory. According to this concept, short-term memory has a rather small capacity and is capable of holding no more than a few things (in the range of 4 to 7). This number can be increased if certain mnemonic techniques are used, such as remembering successive flashes in the form of consecutive numbers. Individuals' abilities also depend on the condition they are in on a given day (e.g. whether they are sleepy, full, relaxed), and on environmental conditions (e.g. the presence of distractions such as noise).

**Keywords:** memory, short-term memory, senses



### Construction of the exhibit

The exhibit consists of a table with and a chair. In the table top there are 6 lamps and – parallel to them, closer to the edge of the table – 6 buttons. Additional elements are two displays with the words 'YOUR RESULT' and 'RESULT OF THE DAY' and a 'START' button.

The exhibit can be used by one person at a time.

### Technical information

**Dimensions: width: 94 cm, depth: 58 cm, height: 75 cm**

**Consumable materials: none**

**Accessories: none**

**Power supply: 230V**

# Memory test

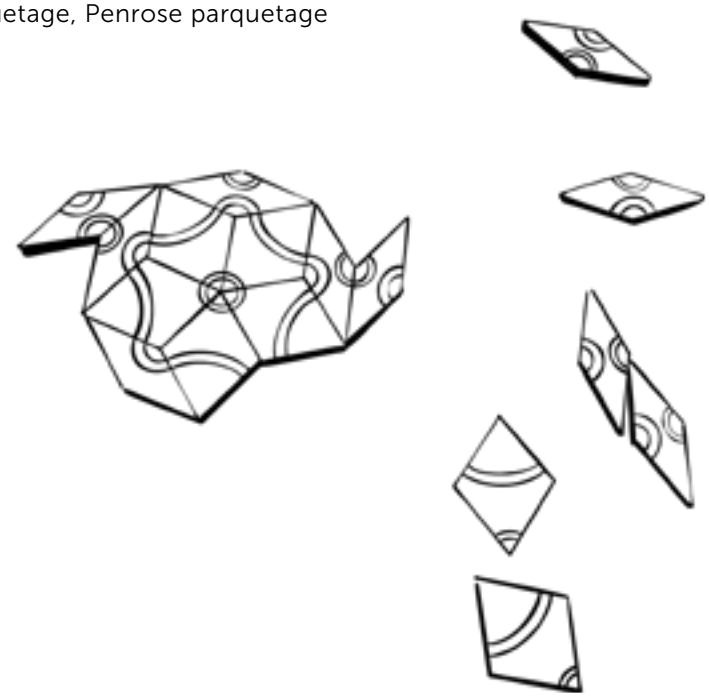
# Penrose tiling

## Is it possible to cover an infinite plane with just two types of figures so that the pattern does not repeat periodically when shifted?

From the available blocks, the user has the task of arranging a pattern on the surface of the base. To obtain a Penrose parquet pattern, one rule must be followed: no two blocks touching can form a parallelogram. By following this rule, the blocks can be used to cover the entire surface without gaps, so that the resulting pattern does not repeat periodically.

Parquetage is the covering of a plane with figures of the same type in such a way that they do not overlap and that there are no gaps between them. In everyday life, we see parquet flooring in pavement motifs (with classic square tiles or cubes of various shapes), in tiling in the kitchen or bathroom or in a bee honeycomb pattern. But is it possible to cover an infinite plane with just two types of figures, so that the pattern does not repeat itself periodically when shifted? Almost 40 years ago, the problem of arranging such a parquet pattern was posed and its various solutions shown by the English physicist and mathematician Roger Penrose. In nature, the equivalent of such non-periodic structures are quasicrystals - materials with an ordered but non-periodic atomic structure, discovered in 1984 by Dan Shechtman, for which the scientist was awarded the 2011 Nobel Prize.

**Keywords:** parquetage, Penrose parquetage



### Construction of the exhibit

The exhibit consists of a wooden base, the surface of which is covered with a carpet.
On the base are two types of rhombus-shaped flat blocks.

The exhibit can be used by a couple of persons simultaneously.

### Technical information

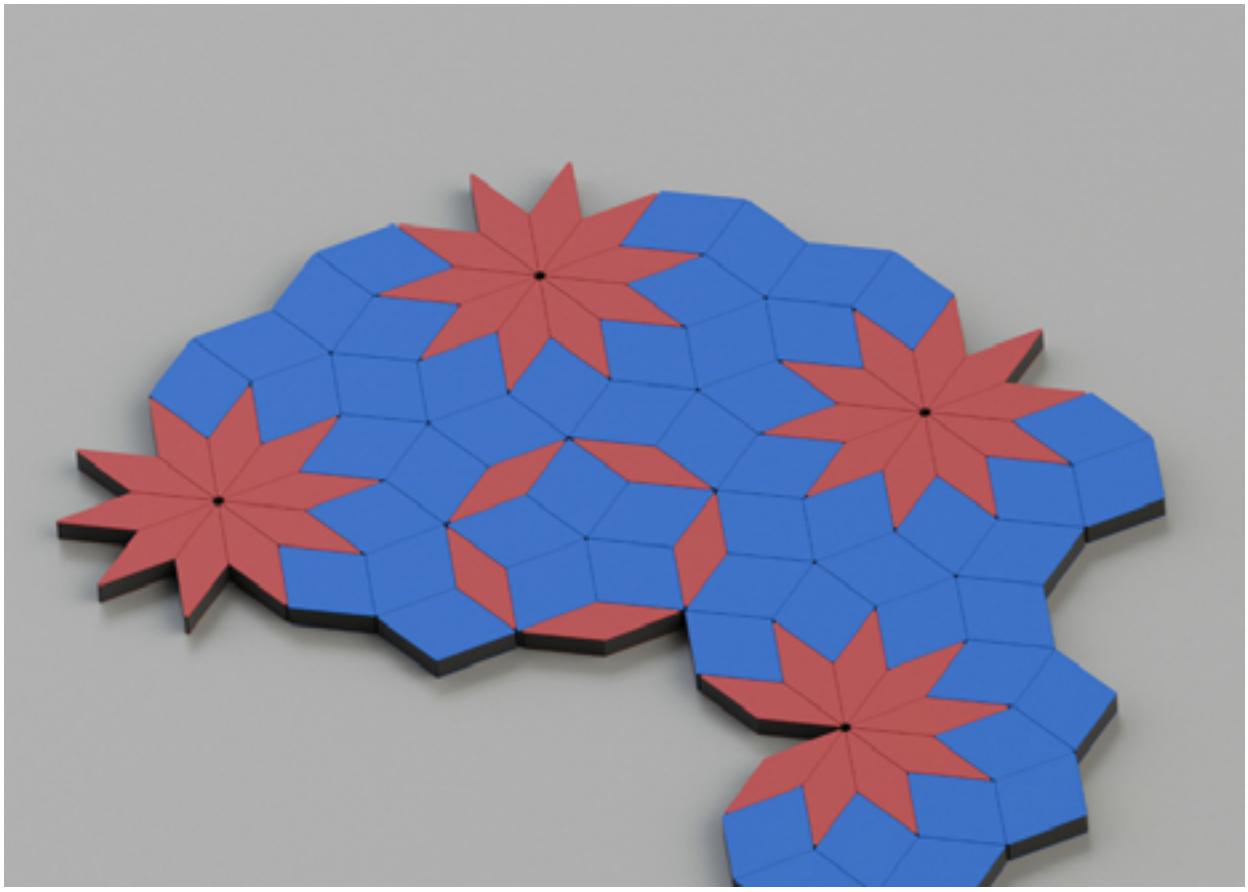
**Dimensions:** width: 200 cm, depth: 230 cm, height: 4 cm

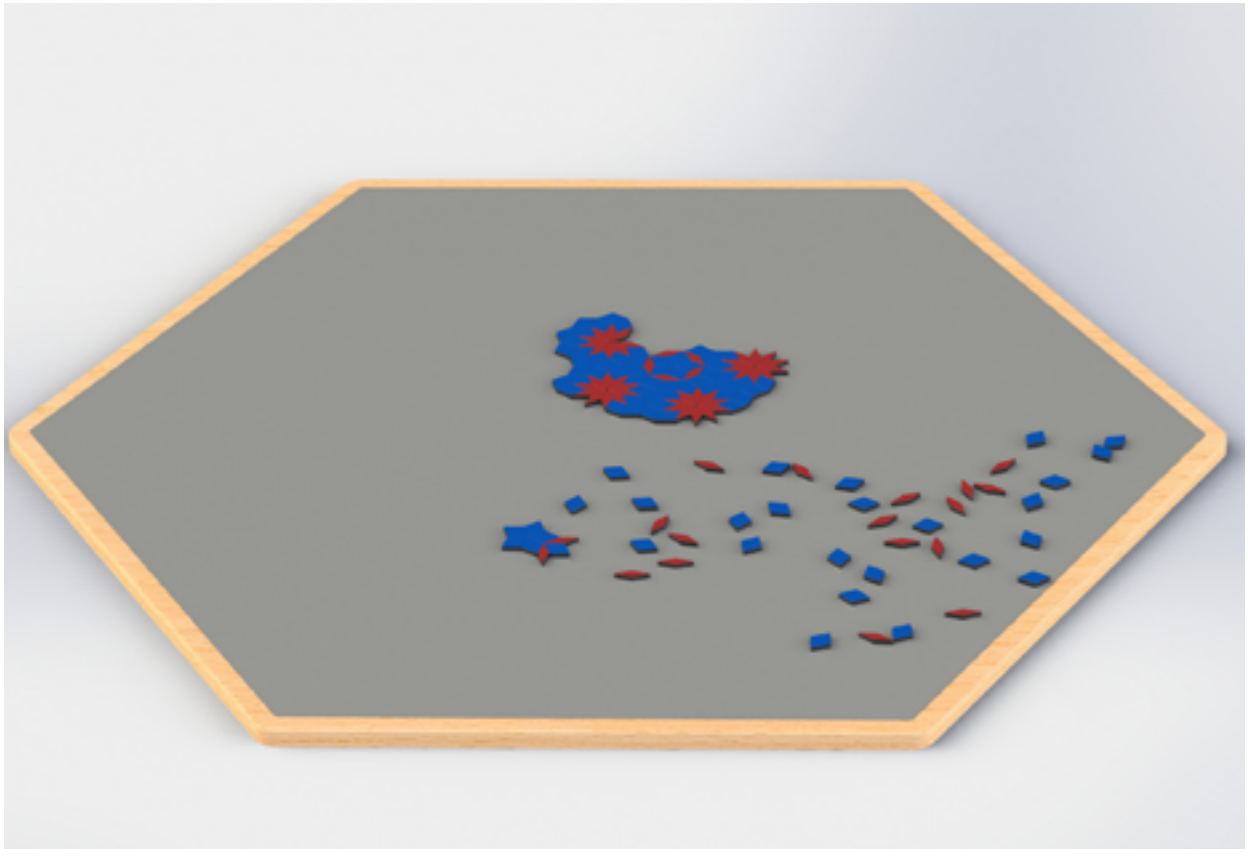
**Consumable materials:** none

**Accessories:** none

**Power supply:** na

# Penrose tiling





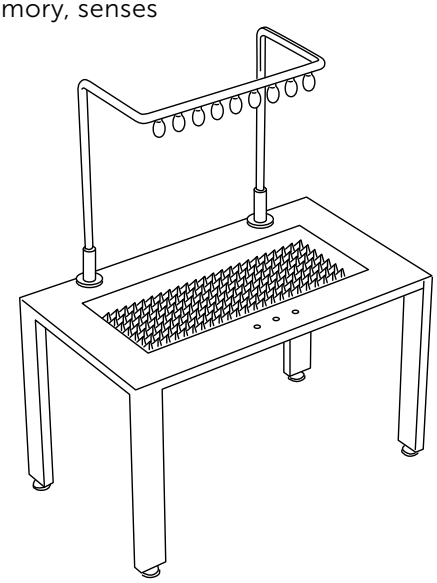
# Catch me if you can!

## Have great fun while testing your reflexes, concentration and motor coordination!

The user has the task of catching the falling eggs in flight before they hit the tabletop.
Before starting the activity, he or she selects the difficulty level (from 1 to 3). When the button is pressed, the eggs fall one after the other in a random order. The variations differ in the time it takes for the eggs to be released one by one - the shorter the interval, the harder it is to catch them.

The user of the exhibit has the opportunity to test his or her abilities: concentration, reaction time (reflexes), coordination and grasping skills. He can also see that these skills can be practised to get better results. The reaction to a stimulus - in this case the movement of an egg released from an electromagnet - is a sequence of events. First, the movement is registered by the eyes (receptors), then the signal is transmitted to the brain, which makes a decision that is then passed on to the muscle movement centre. In order to catch an egg, the hand must move towards the falling object and the muscles of the hand must tighten at the appropriate moment. Finally, the captured egg must be put down in order to catch another egg. Eggs are caught with both hands, so there is a good chance that those more to the right (or left) will be caught more often due to the user's right (or left) handedness. The sum - reaction time, precision of movements, grip and the ability to predict where the egg will be when we are ready to catch it - determines the results of the trials.

**Keywords:** memory, short-term memory, senses



### Construction of the exhibit

There are 7 rubber eggs hanging from a metal frame. Below on the tabletop is a soft mat for the eggs to fall onto. A control panel is mounted in front of the mat, allowing you to select one of three levels of difficulty. The eggs dangle, sticking with their tips to the metal part thanks to the action of electromagnets. When the exhibit is activated, the electromagnets switch off in a random sequence, causing more eggs to fall onto the tabletop.

The exhibit can be used by one person at a time.

### Technical information

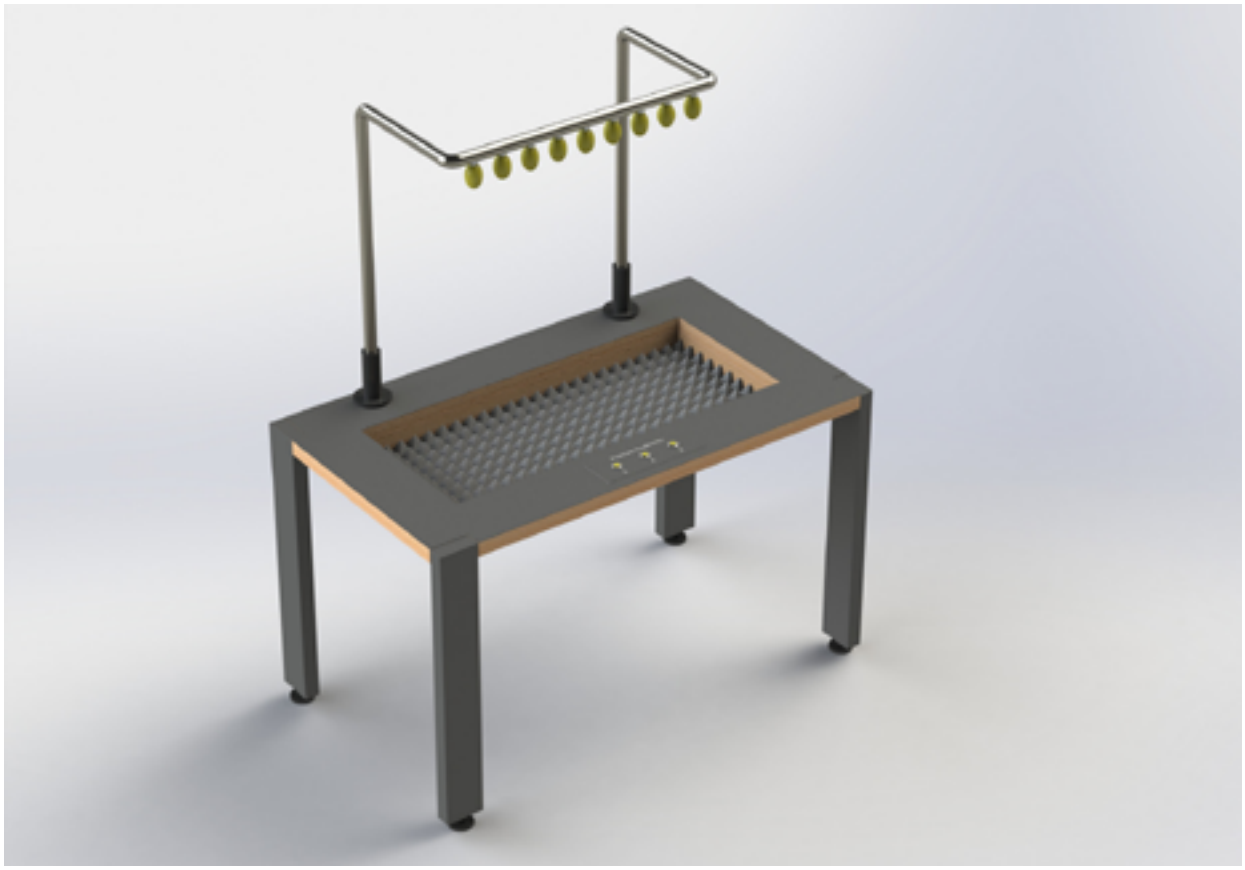
**Dimensions:** width: 125 cm, depth: 73 cm, height: 153 cm

**Consumable materials:** none

**Accessories:** none

**Power supply:** 230V

# Catch me if you can!



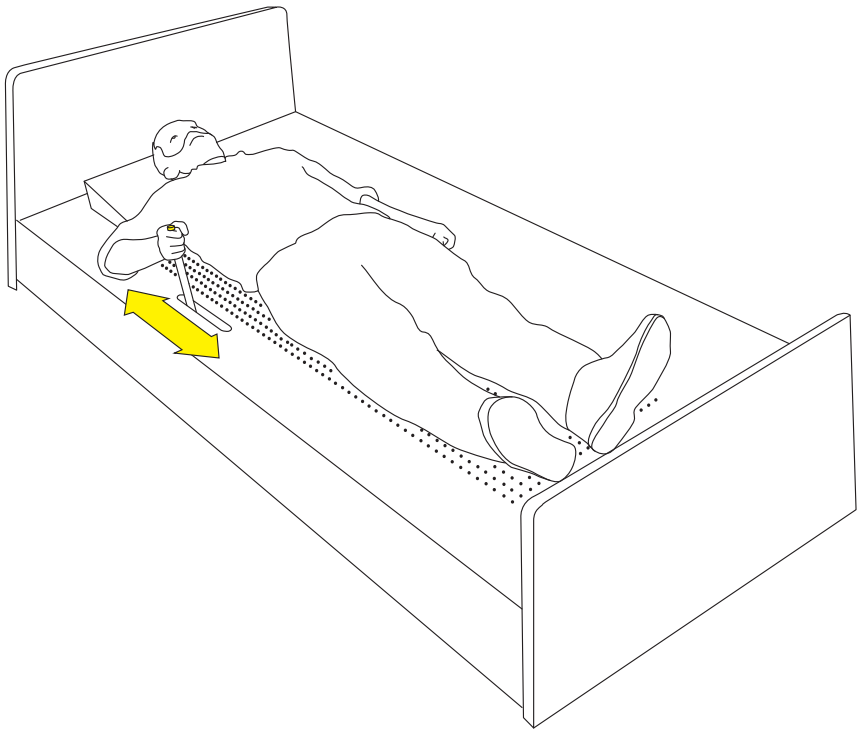
# Bed of nails

## How can lying on nails be comfortable?!

The user is asked to lie down on a flat surface with over 1,000 nails protruding from it, spread evenly over an area of 150 cm × 50 cm (0.75m2). Although instinct tells one not to lie down, it turns out that the bed of nails is not uncomfortable at all. The exhibit provokes cognitive dissonance - a conflict between expectations and reality. It also evokes emotional responses by combining contradictory meanings and associations: on the one hand, the bed is associated with relaxation and safety; on the other, the nails evoke fear and encourage caution. This juxtaposition appeals both to our experiences and to our subconscious threat assessment mechanisms.

A bed of nails provides comfort because the weight of the body is distributed evenly over very many nails, reducing the pressure caused by each nail.

**Keywords:** pressure, surface pressure, pressure distribution, perception, cognitive dissonance



### Construction of the exhibit

The exhibit consists of a wooden bed covered with holes. When you lie down on the bed and pull a lever the nails rise through the holes.

The exhibit can be used by one person at a time.

### Technical information

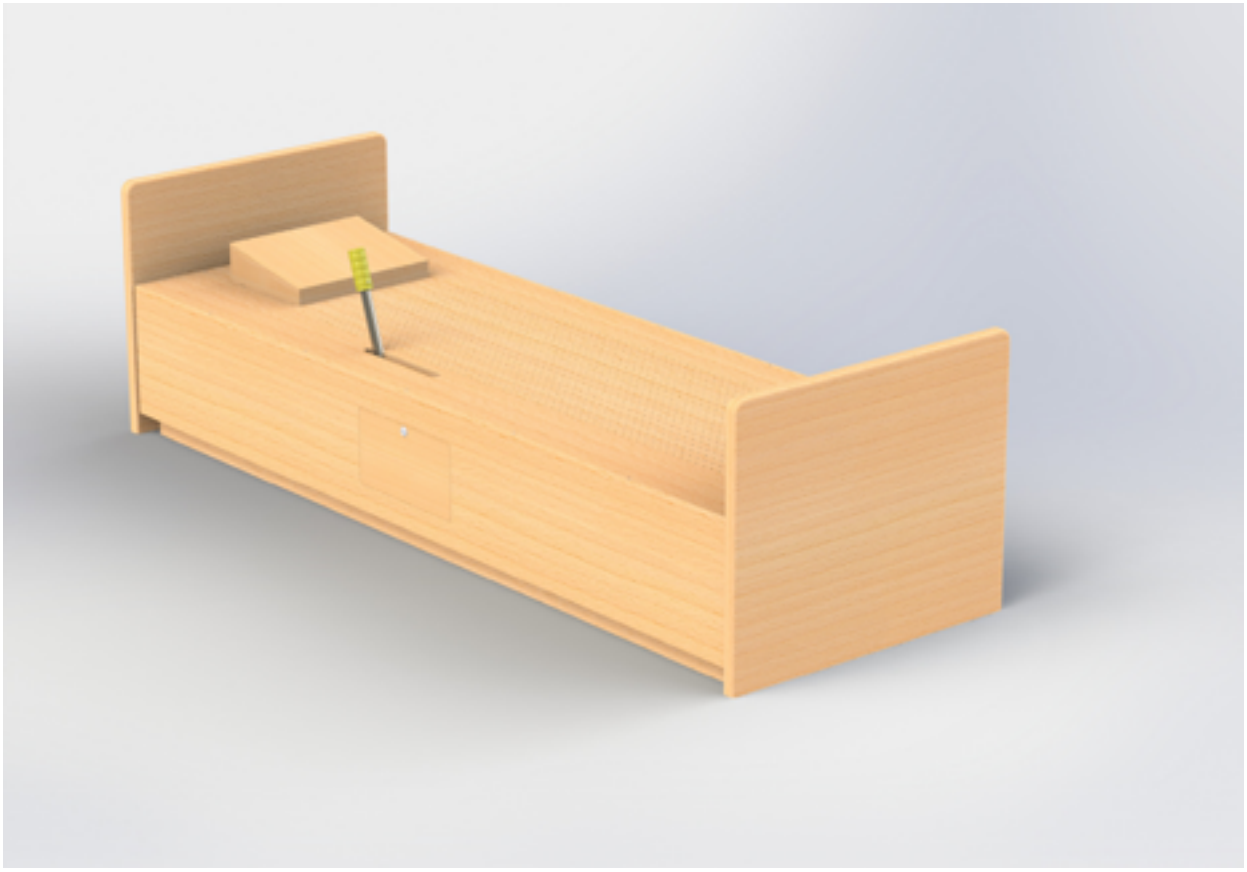
**Dimensions:** width: 81 cm, depth: 232 cm, height: 66 cm

**Consumable materials:** none

**Accessories:** none

**Power supply:** none

# Bed of nails

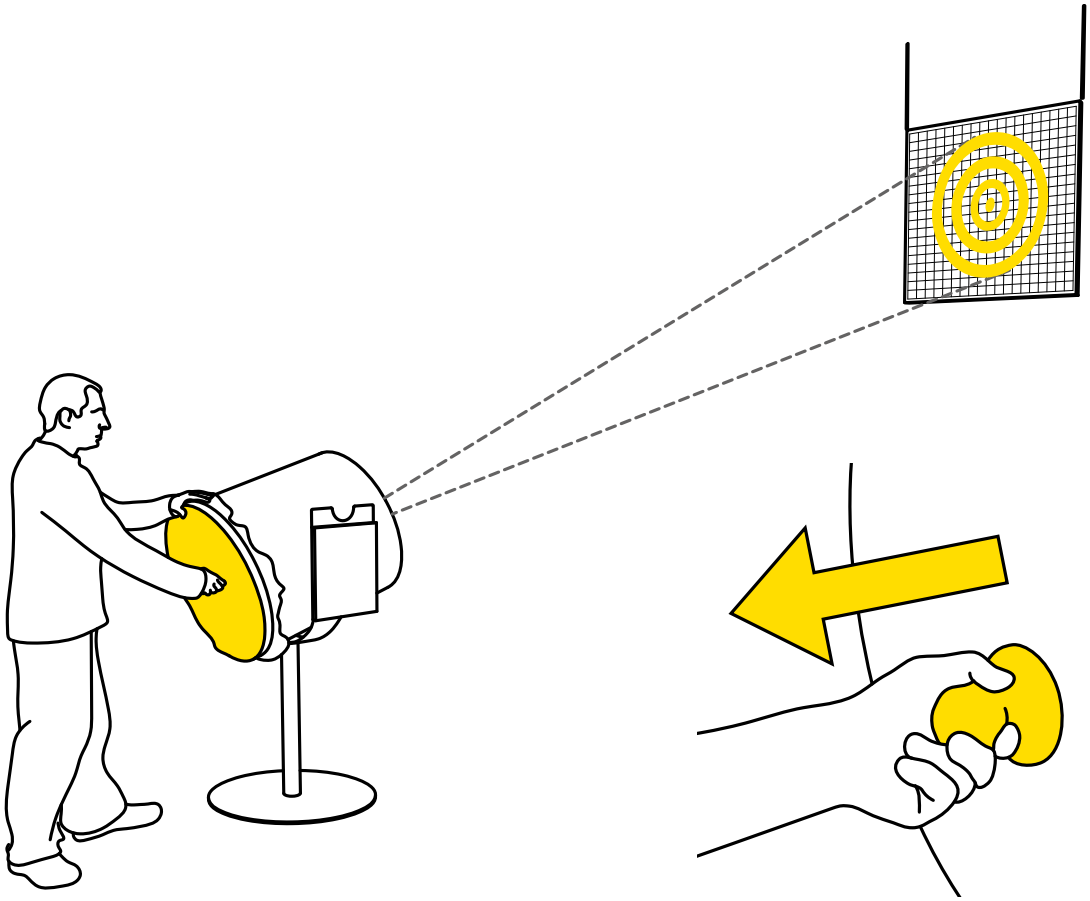


# Air cannon

## Fire an air bullet!

The experimentator directs the "cannon" towards wall made of mirror plates. By pulling and releasing the handle attached to the membrane, they release a large portion of air through a small hole. It's an air bullet – invisible but noticeable. Structure of the drum and air jet make the released air shape into a torus, which looks like a small ring-shaped bun or a lifebelt. This shape can be seen on a board suspended from the ceiling a few metres from the cannon.

**Keywords:** aerodynamics



### Exhibit structure

The exhibit is built of two elements: the first is a wooden cylinder with a membrane, fixed on a stand; the second is a board suspended from the ceiling. The board is made of hundreds of air blow-sensitive elements. Their mirror-like finish additionally creates an interesting visual effect.

The exhibit can be used by one person at a time.

### Technical details

**Measurements:** 60 × 60 cm (cylinder); 150 × 150 cm (board); distance between the cylinder and the board: 5–6 meters

# Air cannon

# Visual concept – Example of an arrangement of the proposed exhibits in space

1. Air Cannon
2. Walking spring
3. Fan
4. Man Puzzle
5. Masters od Instant Memorisation
6. Velvet Hands
7. Rotating Mirrors

# Visual concept – Example of an arrangement of the proposed exhibits in space

1. Fan
2. Mirror Window
3. Rotating table
4. Great Machine

# Visual concept – Example of an arrangement of the proposed exhibits in space

1. Masters od Instant Memorisation
2. Colourful Shadows
3. Two Left Sides
4. Thermal Imaging Camera

# Visual concept –
# Example of an arrangement of the proposed exhibits in space

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