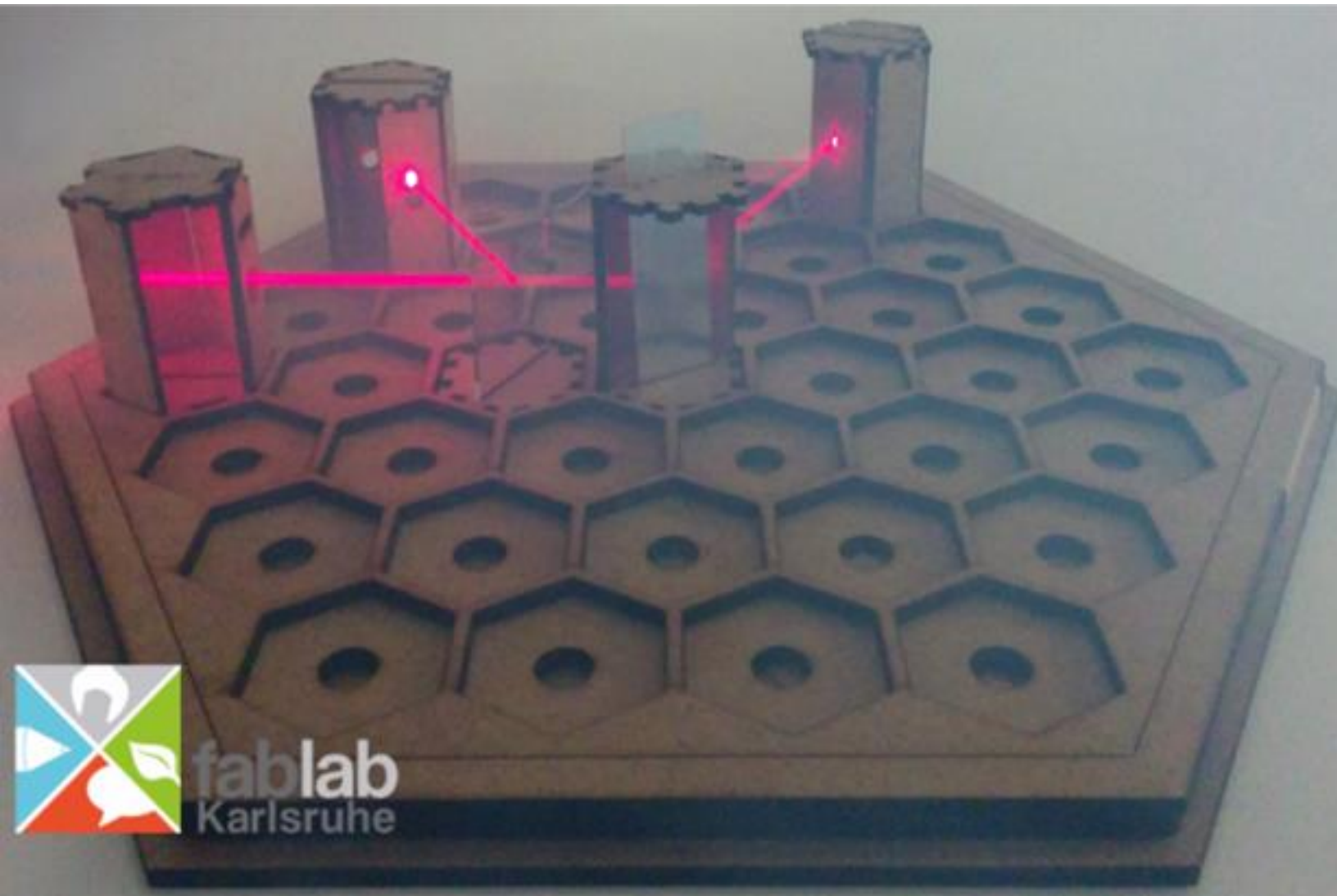


Photonics Workshop

Laser Labyrinth



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PROPERTIES OF THIS WORKSHOP

PHOTONICS WORKSHOP LASER LABYRINTH (FOR INSTRUCTORS)



SUMMARY

The 'laser labyrinth' is a logic maze game that teaches STEM skills. The game requires you to use mirrors, beam-splitters and brainpower to direct the laser through a series of mind-challenging mazes and light up the target. In this workshop the participants will build a version of the laser labyrinth and of course test it in the end. Thus, the workshop focuses on the construction of the game and on the handling of lasers and mirrors.

TARGET AUDIENCE:

Youngsters: 10-14 years



MAX. PARTICIPANTS:

The workshop is most suitable for a group of around 8-10 participants. If you want to perform the workshop with a bigger group e.g. of 18 participants, 5 instructors would be necessary. Further, the workshop would take up to 1 hour longer. The workshop duration also depends on the soldering experience of the participants. If they don't know how to solder, they need a special introduction and attention.

SUGGESTED TIME PLANNING:

In total about 4 hours (depending on how long you keep the introduction part at the beginning of the project and playing part at the end of the project).



TIMING IN MINUTES	ACTIVITY
0-20	Welcome group: Give a short introduction of the laser labyrinth and its theoretical background (law of reflection)
20-45	Step 1: Assembling of the game board
45-120	Step 2: Assembling of the starting figure and target
120 - 200	Step 3-8: Construction of the remaining playing pieces
200-230	Play your own built laser labyrinth and experiment with the reflection
230-240	Closing summary, feedback,..

BACKGROUND

Laser

What do a CD player, a laser printer and a bar code scanner have in common?

Exactly - in all these devices a laser is used. Lasers are an essential part of our day-to-day life and are used in many different devices and places, especially in the industry or in medical devices. In this workshop we will together built the game 'laser labyrinth' where one important component is of course a laser.

What is a laser?

A laser is a machine that makes an amplified, single-colour source of light. The beam of light from the laser does not get wider or weaker as most sources of light do. It uses special gases or crystals to make the light with only a single color. The gases are energized to make them emit light. Then, mirrors are used to amplify (make stronger) the light and to make all the light travel in one direction, so it stays as a narrow beam of collimated light.

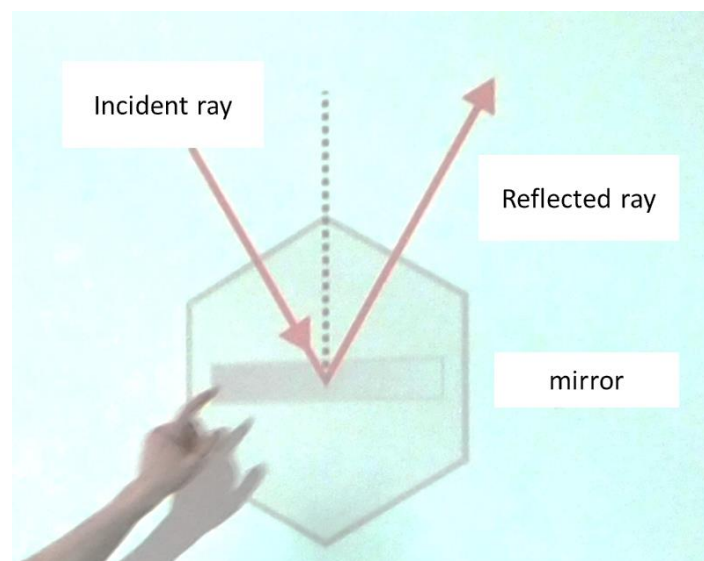
When pointed at something, this narrow beam makes a single point of light. The energy of the light stays in that one narrow beam instead of spreading out like a flashlight (electric torch).

The word "laser" is an acronym for "light amplification by stimulated emission of radiation". (source: <https://simple.wikipedia.org/wiki/Laser>)

The law of reflection

The most important principle the 'laser labyrinth' is based on is the law of reflection. Light reflection in general is very important because it is the reason why we can see anything at all. When a ray of light strikes a medium some of the ray will bounce off the surface. The way the light will be reflected is depending on the surface the light is bouncing off. (The law of reflection: <http://www.physicsclassroom.com/mmedia/optics/lr.cfm>).

According to the law of reflection it is possible to predict, how the light ray will be reflected off the mirror. The law of reflection defines, that the angle of the incident light ray is equal to the angle of the reflected light ray.



The figure above illustrates this principle: The ray of light approaching the mirror is known as the incident ray. When the incident ray strikes the mirror, it will bounce off the mirror. The ray of light that leaves the mirror is known as the reflected ray. The normal line divides the angle between the incident ray and the reflected ray into two equal angles. These angles are always measured from the normal, not from the mirror. The incident ray, the normal at the point of incidence and the reflected ray, all lie in the same plane (Law of reflection; <http://farside.ph.utexas.edu/teaching/3021/lectures/node127.html>)

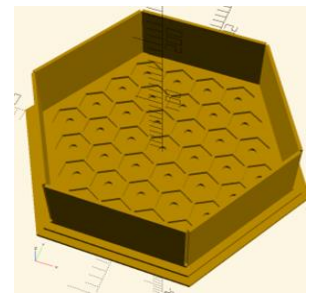
ABOUT THE GAME: LASER LABYRINTH AND ITS COMPONENTS

The game requires you to use mirrors, beam-splitters and brainpower to direct a laser beam through a series of mind-challenging mazes and in the end light up a target.

The game board

The form of the game board is a hexagon, which consists of hexagonal cells. The playing pieces of the game have a hexagonal shape as well, since they have to be inserted into the hexagonal cells.

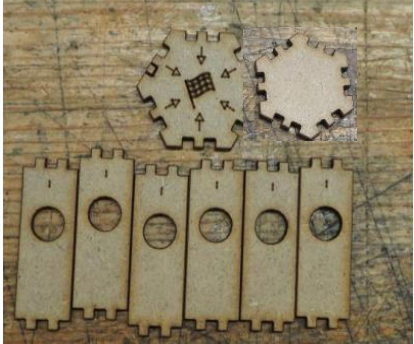



Due to the hexagonal form of the game board cells, the playing pieces can be inserted in six different directions. This offers more challenging possibilities to direct the laser beam through the labyrinth, than a square game board.

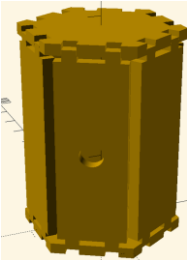
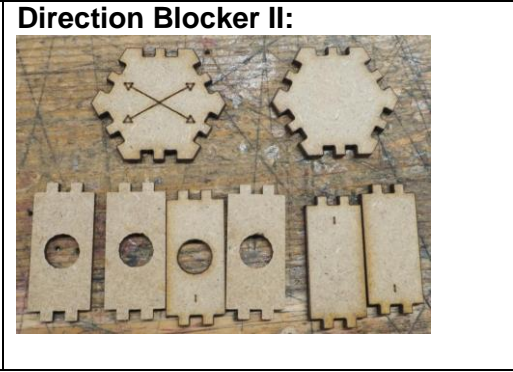
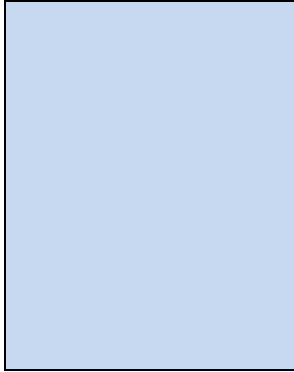


Playing piece Guide:

In total the game laser labyrinth consists of 12 hexagonal playing pieces.

Playing piece	function	components
<p>1x Starting Figure</p>	<p>Provides the laser beam. Push the button at the side wall of this playing piece to engage the beam.</p>	

<p>1x Target</p>	<p>Receives the laser (the goal of the game is to direct the laser beam through the labyrinth in order to hit the target)</p>	
<p>6x Mirror</p>	<p>Reflects the laser. The 6 playing pieces differ in the angle, the laser beam can pass through.</p>	
<p>2x Beam Splitter</p>	<p>Splits the beam into two paths. One path is reflected 90 degrees and the other path passes straight through the playing piece</p>	
<p>2x Direction Blocker</p>	<p>The laser beam can only pass through a limited number of the six possible directions. There is one playing piece, that lets the laser beam pass through two sides and another one letting the playing piece pass through four sides of the playing piece.</p>	<p>Direction Blocker I:</p> 



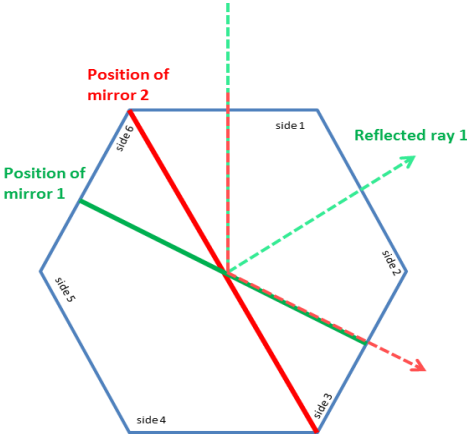
The most important playing piece of the laser labyrinth is the starting figure providing the laser beam. By pushing the button, inserted into one side wall of the playing piece, the laser beam is engaged.

Another important playing piece is the target, which the laser beam has to hit. In order to light up the target you have to arrange the other playing pieces, such as beam splitters or mirrors, in a specific way onto the game board.

For more advanced players: The game will be more challenging with blockers inserted into the hexagonal cells of the game board, as this type of playing piece prevents the placement of any playing piece in that particular cell. Using these different playing pieces opens a big variety in directing the laser through the labyrinth and to the target in the end. However, in this version of the game blockers are not included.

The hexagonal form of the playing pieces make it even more challenging to direct the laser beam. A good dose of brain power and an understanding of science are necessary in order to hit the target. The law of reflection states that the angle of the incident ray hitting the mirror is equal to the angle of reflection. Applied to a hexagon, a laser beam will always hit the hexagon's side perpendicularly. If this principle will be used cleverly, the mirror can be positioned in a way, that the laser beam will pass through a specific side.

More specifically: with only two different mirror positions the laser beam will be deflected on one of the four sides. In figure 9 the incident ray enters the hexagon through side 1 and depending on the position of the mirror, passes through side 2 or 3. By turning the playing piece it is possible to let the beam pass through side 5 or 6. Without a reflection of the mirror the beam would pass through side 4.



Safety

A game with lasers? Is that safe for kids? In this case yes, because several safety measures have been made. Most importantly: so called “eye safe” lasers will be used as laser diodes. In order to create additional safety, the game figures are only supplied with power when they are inserted into the playing cells, thanks to a reed switch integrated in the starting figure. A reed-switch is an electrical switch operated by an applied magnetic field. Thus, in some cells of the game board magnets are inserted. The laser will only be supplied with electricity, when the starting figure with the reed-switch is inserted onto a playing cell with a magnet.

Additionally, every figure and the game board are surrounded by side walls. Moreover, the laser beam can only emerge at certain openings on the side walls preventing from looking into the laser accidentally. We recommend the game to kids aged 10 years and above.

Make sure to give safety instructions, when handing out the laser and especially point out not to look into the laser or point the laser into one's eye, since it can cause bad eye injuries.

PART LIST

Photonics parts:

part	quantity
Eye safe laser diode	1

Electronic parts:

part	quantity
Cable red/black/yellow/blue	10 cm each
tactile switch 6x6mm, height: 7,0mm	1
Reed switch \varnothing 2,2m	1
Lithium button cell battery, 3 Volt, 210 mAh, 20.0x3.2 mm	2
Button cell holder, vertical, PCB version	1

Other parts:

part	quantity
self-adhesive mosaic mirror 10x10mm ²	6 pieces
mirror foil semitransperent	Each set requires two pieces of 2x1cm ² foil.
block magnet 3 mm ³	6

Other parts – standard available in Fablab

part	quantity
wood glue	
glue sticks for hot melt glue gun	
rubber bands	(not necessarily, helps holding the playing pieces together, when assembling them)
tin solder	
Cable red/black	
adhesive tape	
wood panel 1200x600x3mm ³	for Laser cutting the material

screws	2
nuts	2

 **Tools**

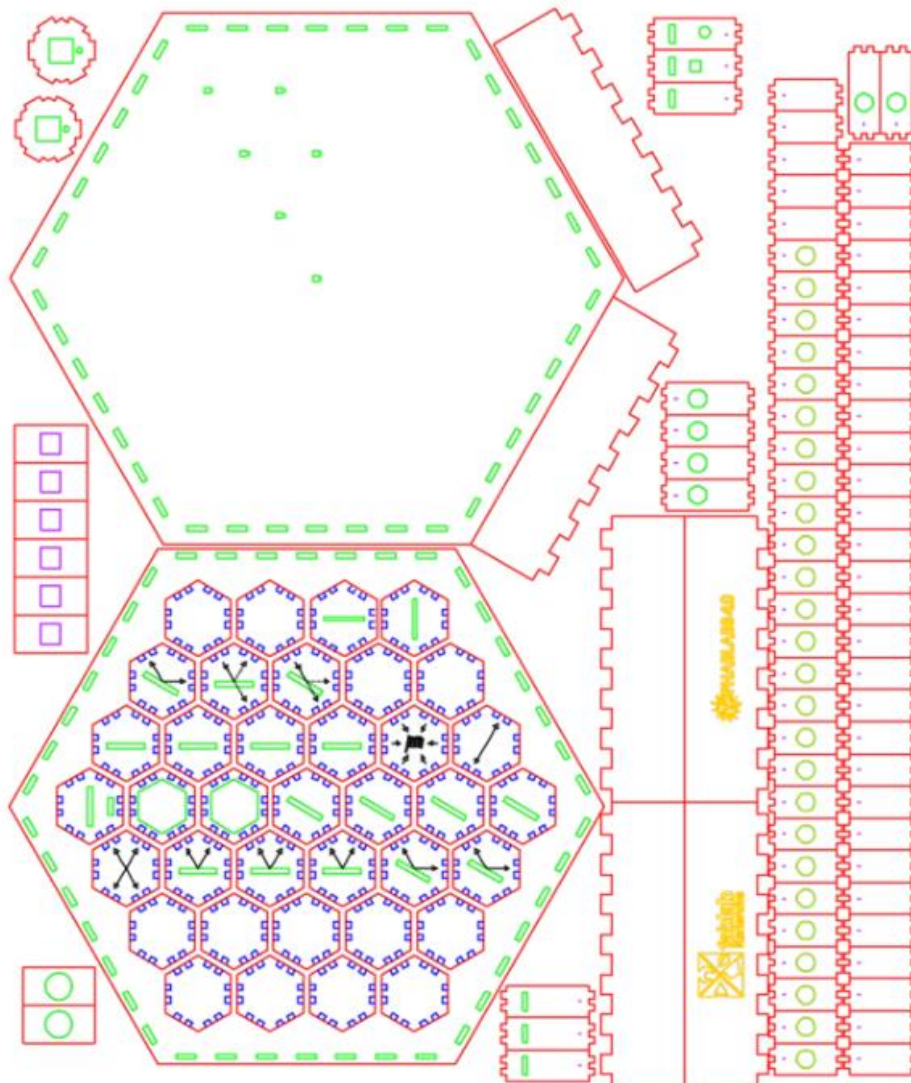
- Laser Cutter
- 3D printer
- Table saw (or something similar in order to cut the mirrors)
- Hot melt glue gun
- Soldering iron and solder
- Diagonal pliers, possibly wire stripper
- Rubber mallet (optional)
- Wood glue
- burn ointment (just in case and to be prepared if a kid get burns with the soldering iron)

PREPARATIONS:

CUT OUT THE DIFFERENT PARTS OF THE GAME WITH A LASER CUTTER

Please note: Cutting the individual game components with the laser cutter takes **about 20 minutes** for one set. Therefore, it is strongly recommended to cut out all the components for the workshop participants before the workshop. To demonstrate the laser cutter, it is recommended to cut a set of one game at the beginning of the workshop, which can then be used for another workshop.

Overview of the laser labyrinth parts for one set:



Please note: In order to save time during the workshop, we recommend to prepare little bags, in which the components for one specific playing piece are already inserted. Thus, the participants won't have to look for the single components, before assembling the playing pieces

together. The corresponding components of the different playing pieces are described in the instructions below and in the playing piece guide on page 5-7.

3D PRINT A SIDE WALL FOR THE STARTING FIGURE

For the Starting figure a 3D printed side wall is needed. Print these side walls according to the details provided to you online.

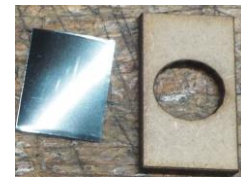
FURTHER PREPARATIONS TO BE MADE:

Besides cutting out the playing pieces and game board with the laser cutter and pack little sets containing the different parts for each playing piece, it is advised, to prepare a few more steps, in order to guarantee a smooth course of the workshop and to minimise sources of errors.

- a) cut off 4 different cables + 2 for the laser diode (ideally one red and one blue) (length approx.: 10cm)
- b) solder cables onto the laser diode (blue cable onto the – pole of the laser diode/red cable onto the + pole of the laser diode)
- c) glue together the two parts of the battery holder (otherwise it won't fit into the starting figure)



- d) cut out a square of the mirror foil semitransparent, so that it will cover the hole of the wood panel.



For all preparation steps around 5 hours should be planned, if material for 15 participants is prepared, since only the laser cutting time is around 5 hours (→ laser cutting time for 1 game=20 minutes)

CONSTRUCTION OF THE GAME BOARD AND THE PLAYING PIECES

STEP 1: BUILDING THE GAME BOARD

The game board consists of 2 layers and will be surrounded by six side walls. The lower field layer is a hexagon, the upper field layer is a grid of several cut out hexagons. The sidewalls of the playing field are mainly used for safety reasons when dealing with the laser.

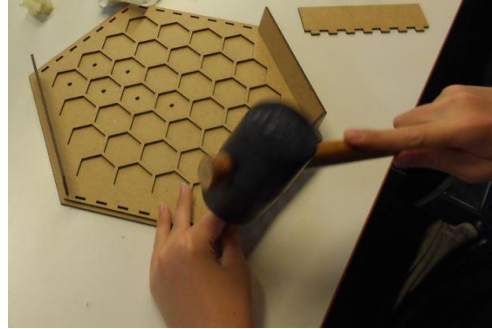
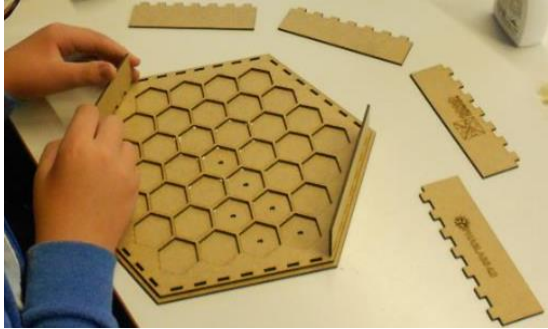


1.1: First, the upper playing field layer (with hexagonal recesses) is glued onto the floor (without recesses) with wood glue. Spread the wood glue drop by drop onto the top layer of the playing field. When sticking together both parts, make sure that both layers are accurately adhered to each other. Make sure, that the holes on the edge of both layers (see marked in red below) lie directly above each other, so that in the next step, the side walls can be inserted into it.

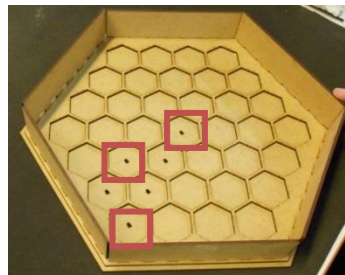


1.2: If there is wood glue swelling out at the hexagonal recesses, it can be wiped away with a damp Zewa cloth or a cable tie.

1.3: In a next step, insert the side walls from above into the holes at the edge of the playing field. Two sidewalls have an engraving, that can be placed either outward or inward. If inserting the sidewalls is a bit difficult, you can help with a rubber hammer to fix them into the game board. Use the rubber hammer very carefully and easily hit on the side walls, so that they do not break.



1.4: After all walls have been inserted into the ground layer of the game board, the gaps between the side walls should be glued together from the outside with wood glue, to make them more stable. After the wood glue has dried in the corners, a masking tape can be glued around the side walls for additional stabilization. At the end of the workshop, the masking tape can be untacked again



The game board is now put together completely. The only components missing to finish the game board are magnets that need to be inserted into the square holes that are engraved in some of the hexagonal cells. Please make sure, for safety reasons to hand out the **magnets** to the participants at the **end of the workshop**. A reed switch on the bottom of the starting block will trigger the laser only when it is placed on a magnet. To prevent the children from carelessly handling the laser at the beginning of the workshop, the magnets should be handed out after the remaining figures have been completed at the very end of the workshop.

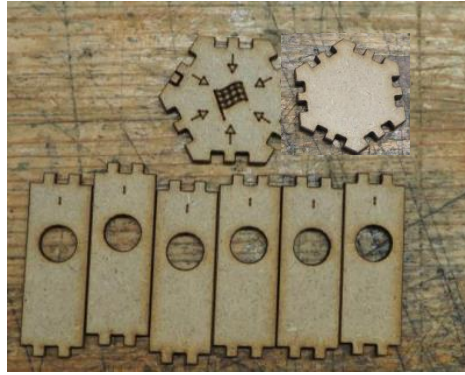
Regarding the order of which playing piece should be put together first: We recommend to start with the target and starting block. The starting block is the most complex figure, since the laser needs to be inserted and the electronics parts soldered together. Moreover, the starting block is the most important figure of the game. Since, it might be too difficult to begin with the construction of the starting figure, we recommend starting with putting together the target figure in order to explain the principle of building the playing pieces.

Another reason to assemble the target and starting figure first, is the possible a lack of time. For the starting figure, soldering work is required and it may be beneficial to do this work as long as the participants are still fit and concentrated. The steps of putting together the other figures, is almost the same for each of them. In case there is a lack of time at the end of the workshop and not all the participants have finished all their figures, they could finish putting together the figures at home as well – with the help of the instructions.

STEP 2: ASSEMBLING THE STARTING FIGURE AND TARGET

It's recommended to put together the target block first, since it is more easy and quickly put together than the starting block.

Components of the target figure: 6 long side walls with hole | one bottom | one cover marked with checkered flag



2.1: Take a side wall and fill the holes of the side walls with hot glue. Thus, the laser light will be reflected diffusely when it hits the target figure correctly and it is clearer to see whether the laser beam hits the target figure or not. When filling the hole with hot glue, make sure that the side on which an **i** (marked in red below) is printed on, is facing up. In order to prevent the side walls from sticking on the table, place a foil onto the table, when filling them with hot glue.



2.2: Once the hot glue in the side walls has dried, the single components of the target figure can be put together. The side walls must be attached to the bottom in such a way that the “i” points down towards the floor, regardless of whether the i points to the outside or to the inside of the playing piece. It is best to put a side wall into the bottom plate first. Then place the cover (with the checkered flag up) onto the side wall and then insert a opposite side wall onto the bottom and cover. When fixing the remaining side walls, it is recommended that opposite sides are always attached one after the other. This will stabilise the playing piece best, while assembling the single

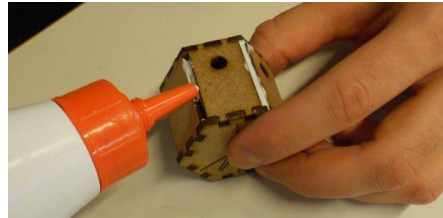


parts.

General note on assembling the playing pieces (applies to all playing pieces):

After each side wall has been put together to the bottom and cover of the figure, the corners of the side walls can be glued together with wood glue making the figures more stable. Remaining wood glue on the side corners can be blurred with either a finger or a damp paper towel. The sides of the wood parts marked with an | always have to face inside of the figure.

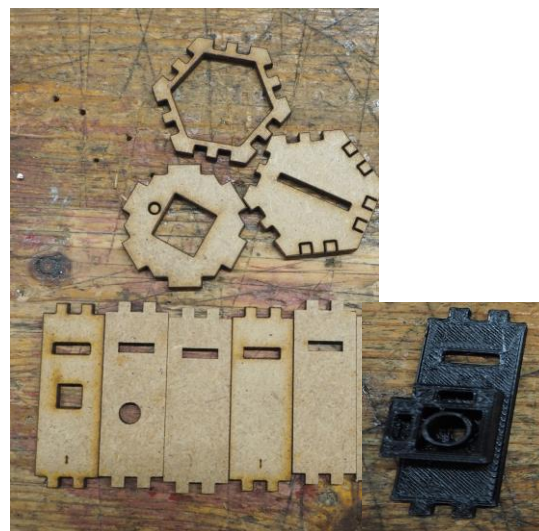
Additionally, a rubber band can be wrapped around the playing pieces, to make sure that they really keep stucked together.



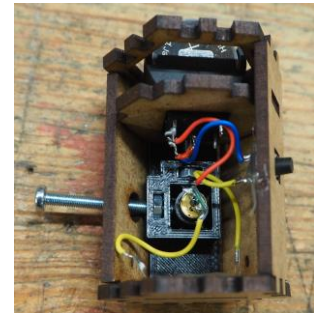
After the target has been put together, the starting figure should be assembled. This step will take up to 60 minutes. What is most time consuming is soldering the electronics and further, the exact alignment of the laser diode. Depending on the soldering experience of the participants and the number of soldering places, assembling the starting figure can take some more time or waiting time for the participants. Please consider this for your workshop planning.

2.3: Assembling the starting figure:

Components of the starting figure: 3 side walls made out of wood | 1 side wall made out of wood with a small hole | 1 side wall with a cut out square | 1 3D printed side wall| 1 bottom bottom with a slot | 1cover (only frame) | 1 cover with a cut out square hole



In addition to the wooden parts, electronics parts are required for the starting figure: laser diode | battery holder | switch | magnetic switch| cable |two 3V button cells



2.4: Soldering of the electronic parts:

Before soldering, the participants should be asked, if they have already soldered and how experienced they are. Even if the participants have a lot of soldering experience, the principle of soldering should be explained with an easy example, to make sure that everyone is more or less on the same level.

safety instructions soldering:

The temperature of the hot soldering iron is above 300 °C (this is three times hotter, as really really hot water). Incorrect handling can cause burns! The following notes have to be considered carefully:

- Carefully lay all power cables on the table so that they can not be damaged by the soldering iron.
- Work on a heat-resistant surface, making sure that there are no flammable objects (such as plastics, wood, etc.) around you.
- Only remove the soldering iron from the holder when everything is ready for soldering.
- Always hold the soldering iron over the table, only solder it over the work board.
- Work in a well ventilated area and use a fume extractor. Do not inhale fumes from the soldering processes.
- Use a third hand, a circuit board vice, pliers, tweezers, or clamps for holding components to avoid burns.
- Do not have food or drink near the working area. The solder is usually a tin/lead alloy and lead is toxic. The flux is a chemical used to help metal parts soldered together. It is acidic and toxic. Clean up spilled flux immediately. Wash hands after soldering. Flux can cause acid burns to the skin or damage clothing. In case of acid burns, flush immediately with water.
- Always return the soldering iron to its stand when not in use. Never put it down on your workbench. The soldering iron tip is very hot (about 400°C). Avoid touching plastic, wire insulator, or any flammable material in the working area with the soldering iron.
- Turn the soldering station to standby or off if not used for more than few minutes. Turn unit off or unplug it when done.
- Dripping solder is very dangerous – even on clothes

More information: <http://www.riccardobevillacqua.com/SolderingSafety.pdf>

Soldering the electronic parts of the starting figure:

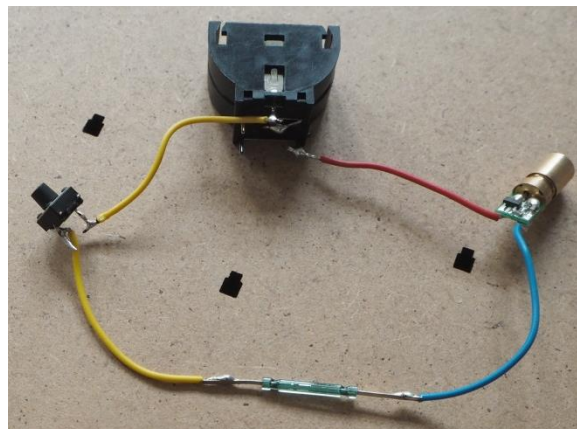
Solder the individual parts according to the following order:

Yellow cable → reed switch → yellow cable → button → yellow cable → Battery holder - **pole** → blue cable → reed switch → blue cable → laser diode - **pole** → red cable → laser diode + **pole** → red cable → battery holder + **pole**

You can find a more detailed step-by-step explanation below:

- First, take the resistor and bent the legs of it a little bit. Next, solder the yellow cable onto one leg of the resistor.
- Then, solder onto the yellow cable's end the button. In this step it doesn't matter on which of the four legs the yellow cable is soldered to.
- However, it is important that in the next step, the yellow cable is soldered to the diagonally opposite leg.
- Solder this second yellow cable, onto the - pole of the battery holder.
- Solder the reed contact (soldered together already on the yellow cable) onto the blue cable.
- Now laser diode will be connected. Take the end of the blue cable and solder it onto the - pole of the laser diode.
- The plus pole of the laser diode will be soldered onto the red cable.
- One missing connection lies between the + pole of the battery holder and the red cable, connected to the +pole of the laser diode. Connect the red cable fixed on the laser diode onto the + pole of the battery holder.

The electronic components of the starting figure should look like this now:

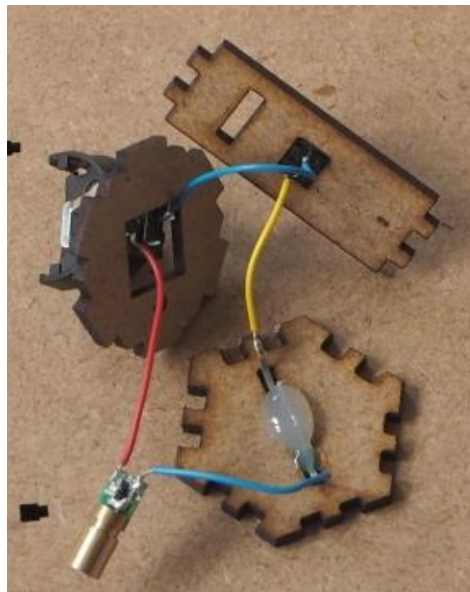


2.5: After the electronics have been soldered together, these components need to be surrounded by the side walls, cover and base plate. Take the cover plate (with a square hole)

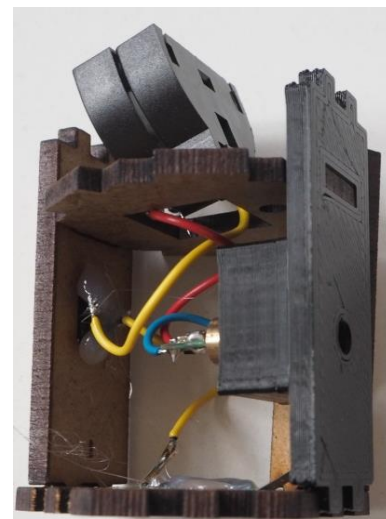
and place all electronic components through this hole, except the button cell holder which needs to be placed outside of the playing piece. Once the button cell holder sits on the cover plate, we can continue with fixing the reed switch into the bottom plate.

2.6: The reed switch needs to be fixed onto the slot of the bottom. With a little bit of hot glue, the reed switch can be attached to the hole on the floor.

2.7: Next, the button which fires the laser beam should be placed through the square hole, found on one of the sidewalls. The button must be operated easily from the outside, so be careful, when inserting the button through the square slot. Make sure, that the button is not stuck inside of the figure. Pliers can be helpful to pull out the button, if it is stuck too much inside. If the button sits well, it can be fixed using the hot glue gun.



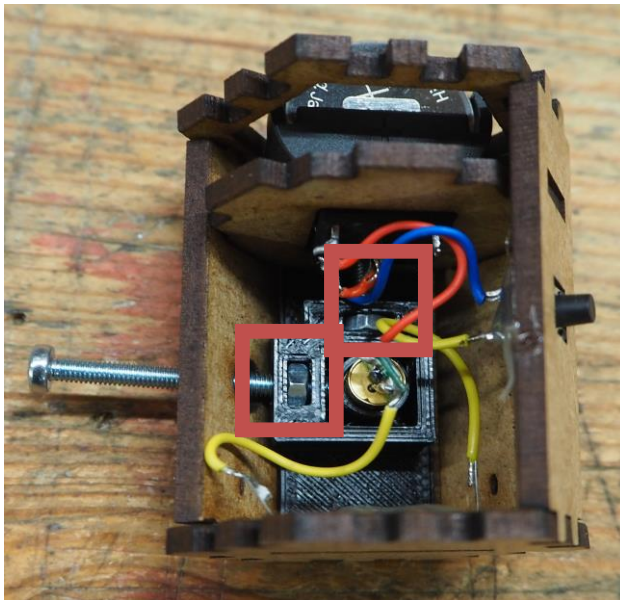
2.8: Next, the laser diode is inserted into the hole of the 3D printed sidewall. Place the laser diode through the hole of the 3D printed wall as wide as possible. Place the side wall onto the bottom and cover plate and repeat this step with the wooden side wall containing the button. is inserted onto the bottom plate on the opposite side of the just inserted wooden side wall.



2.9: Insert the two nuts into the corresponding fixture of the 3D printed wall (marked with red squares in the image below). Insert the two screws into the nuts. One screw is inserted through the hole of the side wall and the other screw is inserted through the open cover plate. This mechanism will help you to adjust the direction of your laser diode.

The remaining side panels shall be tacked together, once all the electronics have been inserted into the starting block.

The starting figure together with the soldering of the electronics is now completed. To operate the laser diode, insert the batteries into the battery holder.



In a next step, the alignment of the laser diode, needs to be adjusted, to guarantee, that the laser beam optimally meets the target figure.

We recommend distributing the batteries and thus, aligning the laser diode at the end of the workshop. This will prevent the participants from playing with the laser before finishing all other steps of the workshop. Another safety step is to distribute the magnets at the end of the workshop as well. The magnets need to be inserted into the corresponding holes in the game board. Only with the magnets inserted in the fields, the laser beam will be triggered through the reed switch.

We will continue now with assembling the other playing pieces. At the end of the workshop, we will align the laser diode. This step will take around 8 minutes per participant. If you are short on time at this stage of the workshop, we recommend starting with the alignment of the laser diode now. If you first undertake the alignment of the laser diode, before finalising the other steps, make sure to recollect the distributed magnets and cell batteries.

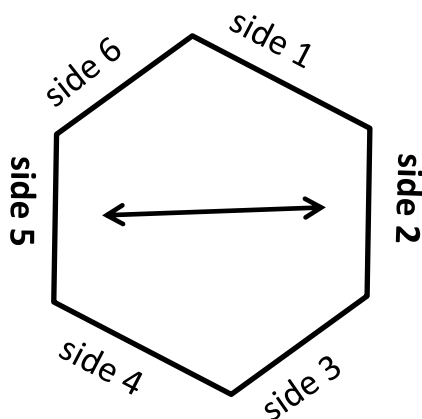
STEP 3: ASSEMBLING THE PLAYING PIECES “DIRECTION BLOCKER I”

Components of the cell blocker: 2 side walls with a hole | 4 side walls without a hole | 1 bottom | 1 top with the following engraving: ↔



The direction blocker is a playing piece with only one forward direction, so only two side walls with a hole are needed.

The engraving on the cover of the playing figure indicates, where the side walls with a hole need to be inserted: in each case the sidewalls should be inserted at the side the arrows are pointing to - opposite of each other. Place the two side walls with holes e.g. on side 2 and side 5 of the cover (see figure below) It is important, that you stick the side walls into sides that lay opposite to each other. When sticking the side walls on the cover make sure, that the arrows engraved on the cover point towards the side walls with holes. After fixing the side walls onto the cover, place them into the bottom plate. Then, the four remaining side walls (without holes) can be stuck into the cover and bottom plate.

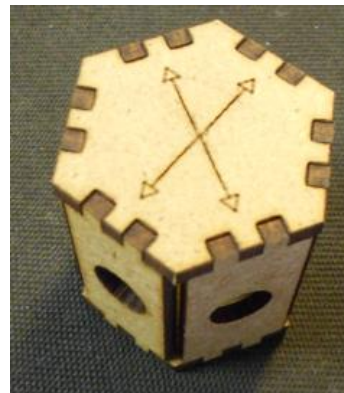
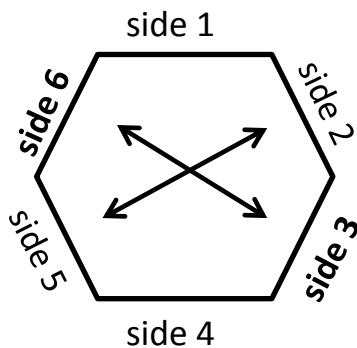


STEP 4: ASSEMBLING THE PLAYING PIECE „DIRECTION BLOCKER II“

Components of the „direction blocker“: 4 side walls with a hole | 2 side walls without holes | 1 bottom | 1 cover with the following engraving:



First, put two opposite sidewalls with a hole, onto the bottom (for example, side 3 and side 6). Then place the cover plate onto the side walls. Make sure, that the arrows engraved on the cover plate, will point onto the side walls with the holes. The two other side walls with a hole should be placed also on two opposite sides, on which the other arrowheads are pointing to. Finally, the two side walls without a hole will be stuck into the remaining sides.



STEP 5: ASSEMBLING THE PLAYING PIECE „MIRROR I AND MIRROR II“

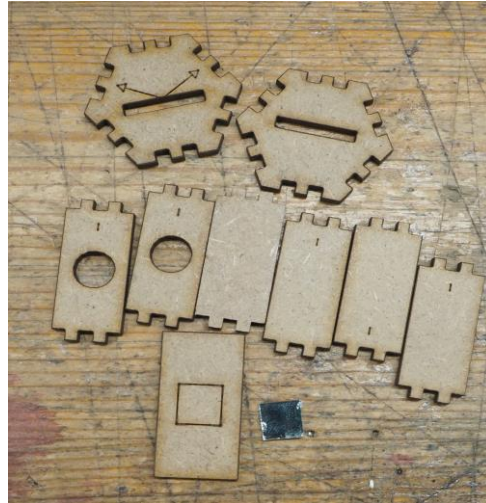
In total, there are two different versions of the playing piece “mirror” in the game. They differ in the angle of refraction, recognizable by the arrow engraved on the cover. There are three pieces per mirror variation in the game, so in total there are 6 mirror playing pieces in the game.

All mirror playing pieces are build the same way and can be put together by the participants independently. Participants should be advised that they should assist other participants once they have assembled their own mirror playing pieces.

Components of the playing piece mirror: 2 side walls with a hole | 4 side walls without a hole | inside wall with engraved square | bottom with a slot | cover with a slot and engraved arrows | self-adhesive mirror plates



Components of „mirror I“



Components of „mirror II“

5.1: Take the inner wall, on which a square is engraved. On this wall, the mirror will be placed. Carefully remove the mirror plate from the foil and stick it onto the square. Before assembling the different parts of the playing piece, it is important to check, that the slots in the bottom and top panels match. The mirror inner wall must be inserted into the bottom plate in a way that the plate is flush with the center line on the bottom. If this is done, stick the cover on top of the inner wall.



5.2: Now each of the side walls can be inserted into the cover and bottom. The side walls with hole are inserted on the side pointed to by the arrow engraving on the cover, because the laser beam needs to appear through this hole.



5.3: Putting together the other version of the mirror playing piece follows the same steps as just described, the components only differ in the engraving on the cover plate:

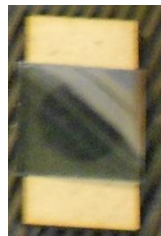
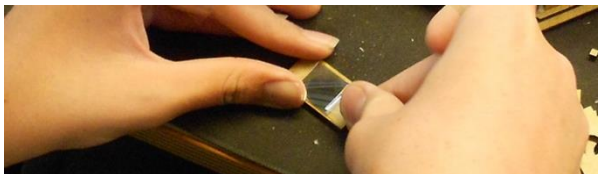
STEP 6: ASSEMBLING THE PLAYING PIECE „BEAM SPLITTER“

Components of the beam splitter: 3 side walls without a hole | 3 side walls with a hole | inner wall with an extra large hole | bottom with a slot | cover with a slot | semi-transparent mirror foil



The beam splitter splits the laser beam into two parts and emits in two different directions.

6.1.: Stick the semi-transparent mirror foil on the inner wall with the extra large hole. Place the foil over the hole and make sure, that the complete hole is covered with foil. Fix the foil with scotch tape across the edge, stretch the foil well. When gluing, be careful to only touch the edge of the foil to avoid fingerprints in the middle of the foil.



6.2.: Insert the inner wall into the slot of the top and bottom part as described in step 5.1. The slots of the cover and bottom parts must be identical and shouldn't be mixed up with the components of the playing piece "mirror".

6.3.: Insert the side walls with hole, again onto the side pointed to by the arrow engraved on the cover. Make sure, to first place the side walls into the bottom plate and then, stick them into the cover plate.

All playing pieces should be completed now. If you haven't adjusted the laser diode, already, you should continue with this step now.



Collection of the different playing pieces

STEP 7) ADJUSTMENT OF THE LASER DIODE

The laser diode should be adjusted carefully, in order to make the laser beam hit the target correctly.

For adjusting the laser diode, the target figure is needed. Place the starting figure with a approx. 1m distance apart each other, opposite the target figure. To make the laser beam better visible, it will help to place a cardboard/wooden plate behind the target (as seen in the picture below). Keep turning the screws, until the laser beam hits the holes of the target figure directly.



STEP 8) INSERT THE MAGNETS INTO THE PLAYING FIELD

After all the playing pieces have been put together and the laser of the starting figure has been adjusted, the magnets can be inserted into the playing field. Simply put the magnets in the holes of the game board. Then, use the starting figure to test whether the right side of the magnet is pointing upwards and the reed switch is triggering the laser beam when the starting figure is placed on the magnet field. If the laser beam does not light up, the magnet must be turned the other way round. Test until the laser beam is triggered.



When all magnets are properly inserted, secure the magnets with scotch tape. Then turn the game board the other way round and fix the holes, where the magnets are sitting in, on the back side with wood glue.



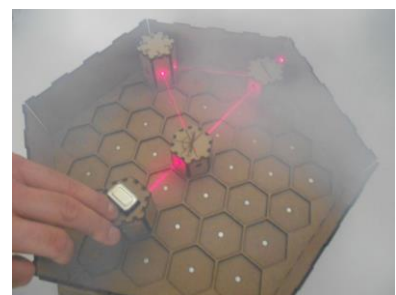
STEP 9) SOLVE THE PUZZLE TASK

The construction of the laser labyrinth is now completed and the participants can experiment a bit and solve puzzle tasks. As a very last step and especially for fun, the fog machine can be started. This makes the beam of the laser more visible and creates a mystical atmosphere.

This simple webeditor can be used in order to create some puzzle tasks for the participants:

(Left click changes field type, right click rotates. Save, save the field in the local storage of the browser under the selected name)

http://weinreuter.org/ll_editor/



Last step: End result & conclusions

What we learned?

- Safe handling of lasers
- How will a laser beam behave when it hits a reflective surface? (principle: law of reflection - the angle of incidence is equal to the angle of reflection)
- Light is steerable and it can be redirected with mirrors in almost any way
- Light can transmit information (note: a PWM-modulated beam triggers only some targets)



PHABLABS 4.0 is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:

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