LEGO-Interferometer

Institut für Didaktik der Physik

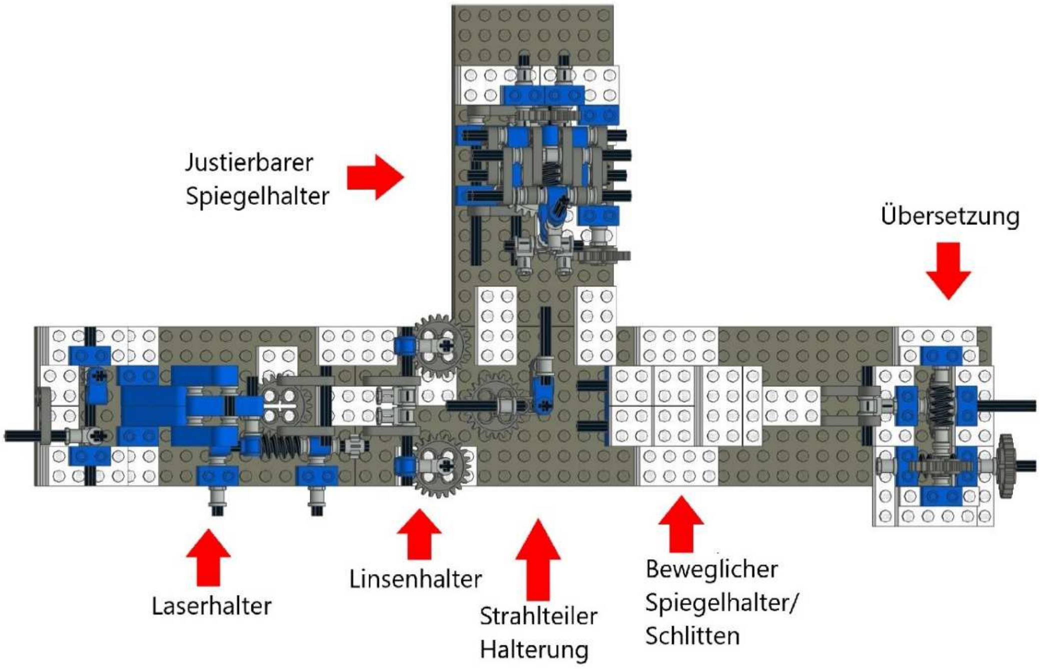


Abbildung 1: Das Interferometer aus LEGO-Steinen.

INTRODUCTION

The interferometer built from LEGO-bricks was developed for usage in schools. All parts can be build by students using LEGO-manuals in about 15 minutes.

This manual will describe how the additional **optical components** can be added to the LEGO-construction. In addition to that, the calibration process of the interferometer is explained.

PREPARATION

- Function of a Michelson interferometer.
- Mathematical relation between the wavelength of light and the translation of the mirror (see the end of this manual).

COMPONENTS

- LEGO-bricks *or* already built components
- 1x Hama Laserpointer LP18
- 2x Front surface mirror 30mm x 20mm,
- 1x Semi-transparent front surface mirror
- Glass lens, diameter *d*=18mm, *f*=26,5mm
- Hexagon screw M5 x 40mm
- Rubber bands

IMPORTANT INFORMATION

Before adding the parts, please be aware that the optical components are very prone to damage and therefore have tob e handled with care.

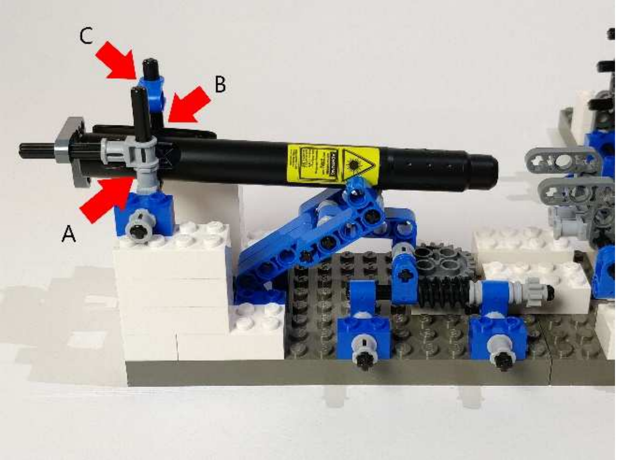
The quality of the interference patterns will be disrupted by fingerprints on the lens or the mirrors. The experiments use front face mirrors (→ why?). These are coated and the coating should not be touched if possible. Cleaning of the optical components is not to be done by using common handkerchiefs (→ why?)

0. ASSEMBLY

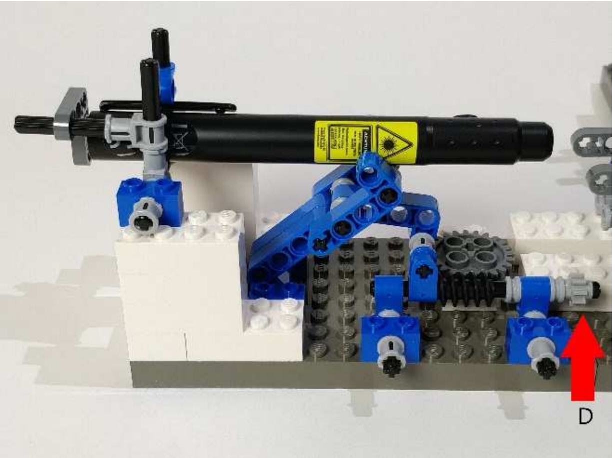
Build the components of the LEGO interferometer by using manuals 1-4. **Should the components already be assembled, please connected them as shown in figure 1** and continue with the steps for adding the optical components.

1. ADDING THE LASER

Put the laserpointer into the laser mount as shown and fixate it at the back end by using the movable parts A, B and C.

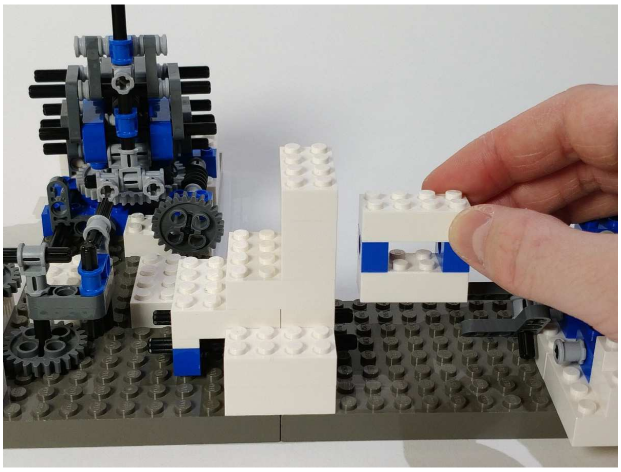


By using the gear, adjust the laserpointer into a horizontal position.

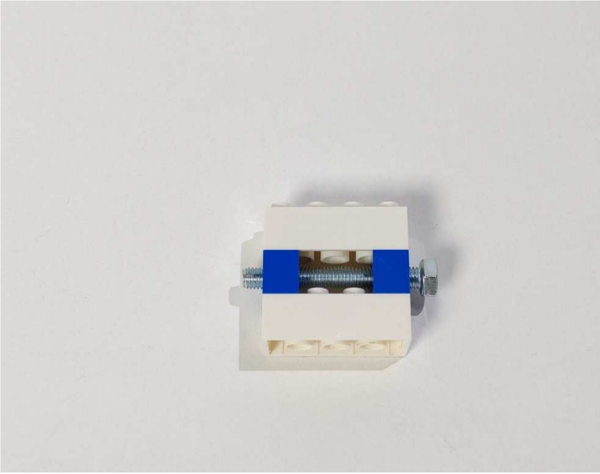


2. ADDING THE SCREW

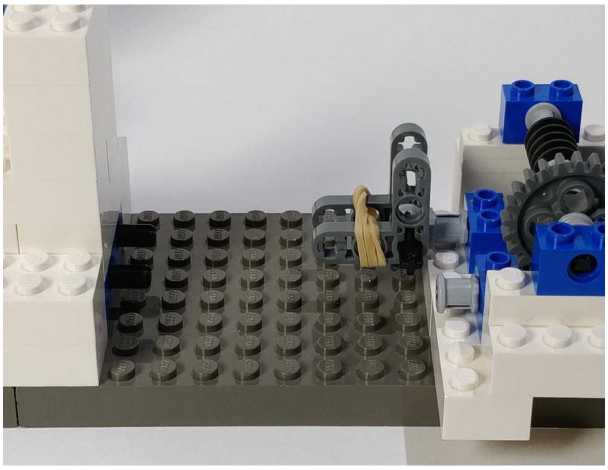
Remove the bricks as shown.



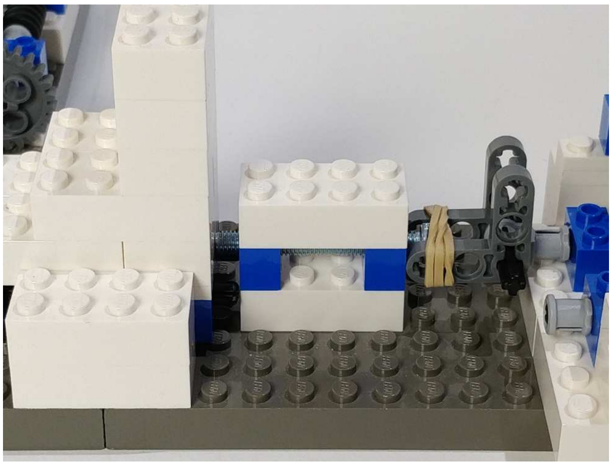
Guide the M5 screw through the holes in the blue bricks.



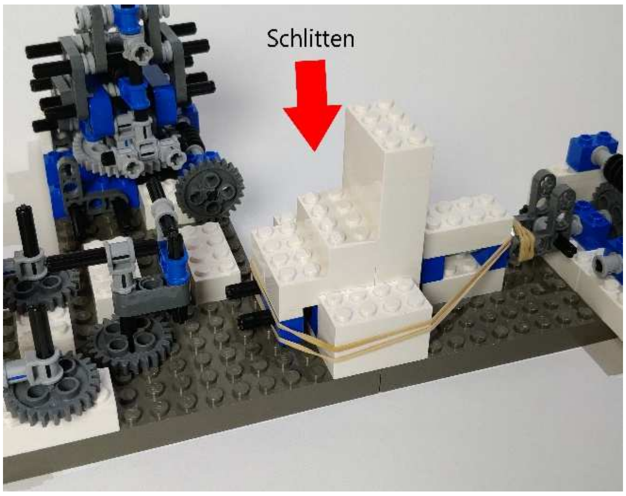
Put a rubber band several times around the two angles to give additional support to the screw.



Put the bricks with the screw back at its former place. The head of the screw will be put between the two angles as shown.

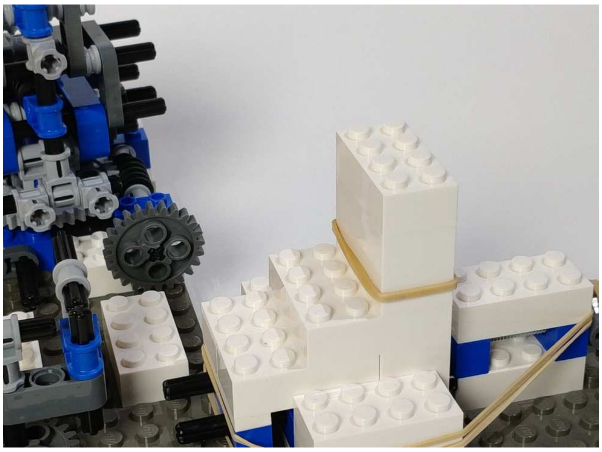


Wind two rubber bands around the sled and the screw's mount so that the sled is pressed against the screw as shown.

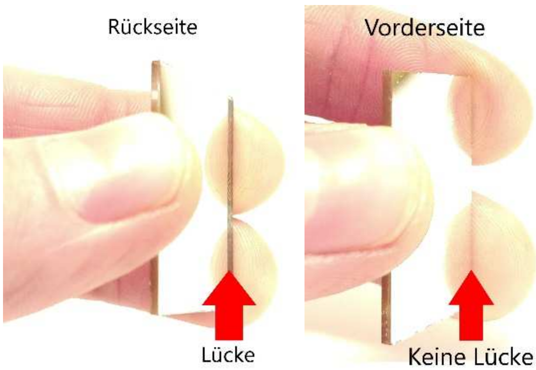


3. ADDING THE MOVABLE MIRROR

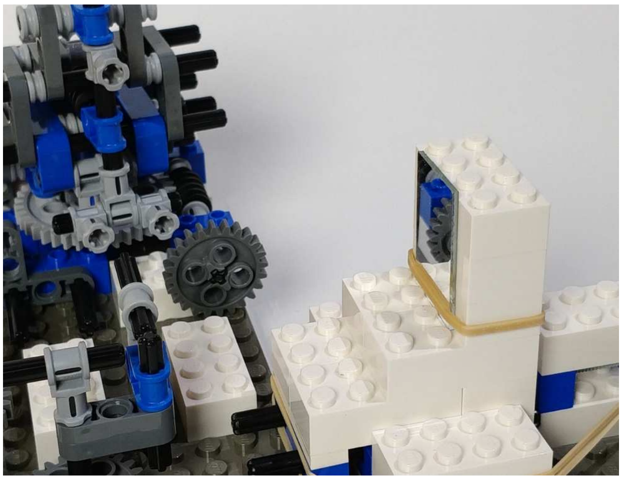
Wind a rubber band around the LEGO bricks that the mirror will be placed against. Pull down the rubber band to the base of the bricks.



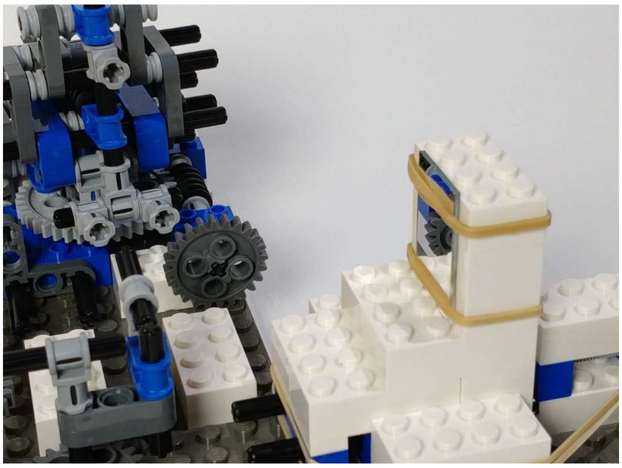
Determine front and backside of the front surface mirror. Hold the mirror as shown in the picture.



Slide the mirror between the rubber band and the bricks. The back surface should point towards the bricks.

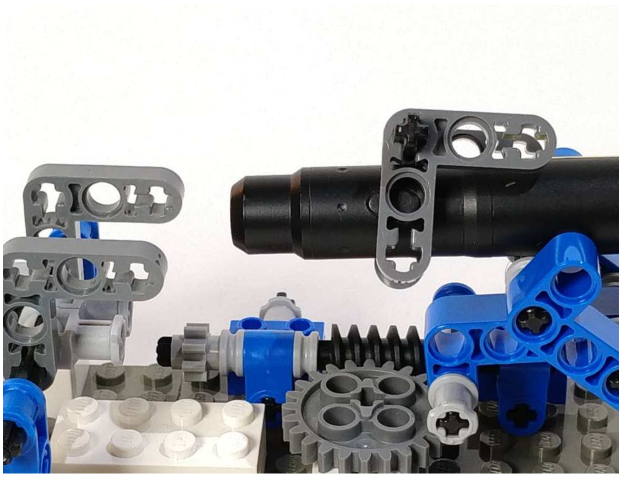


Wind a second rubber band around the top of the bricks and the mirror.

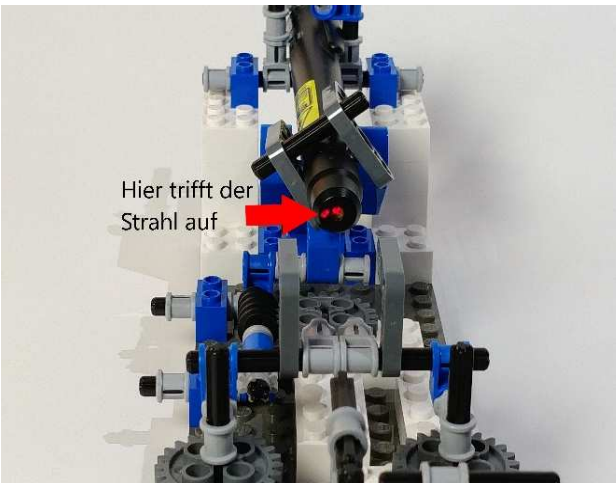


4. CALIBRATING THE LASER

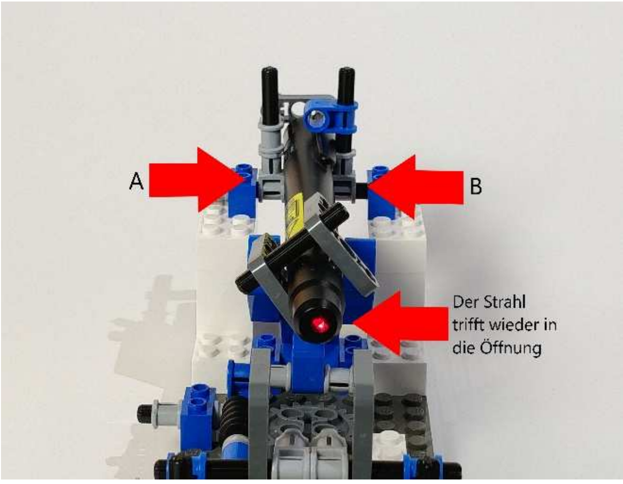
Switch on the laser pointer. Use the clamp to permanently have the button pressed.



Adjust the laser pointer by using the gear D. The laser must be reflected back to the pointer at the same height as it is leaving the pointer.

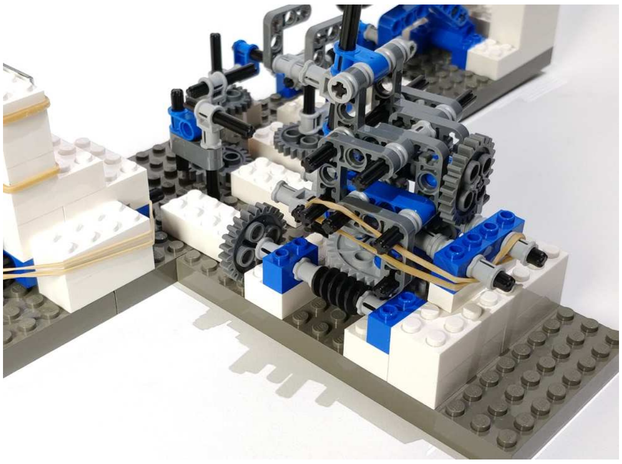


Correct the laser's horizontal angle by using parts A and B so that the laser is reflected exactly back into the opening of the pointer. **Switch off the laser pointer.**



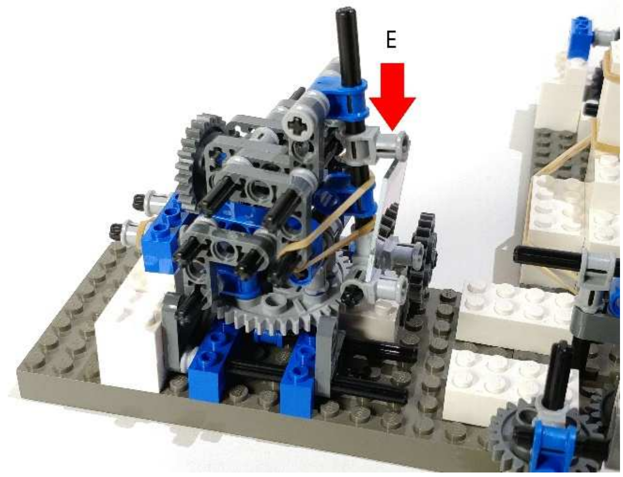
5. ADDING CALIBRATABLE MIRROR

Secure the mirror mount with a rubber band against the play during sideways rotations.

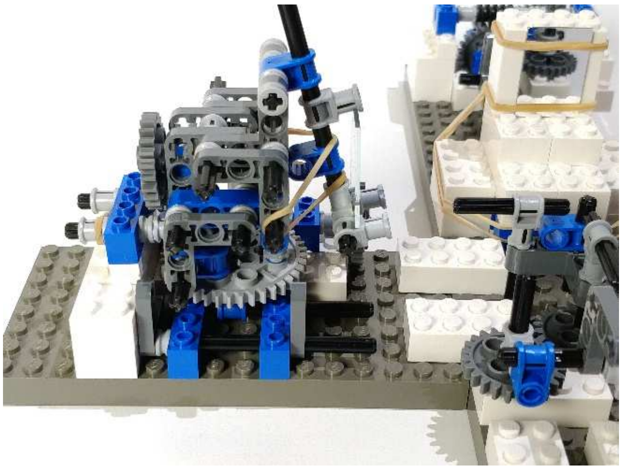


Place a rubber band in front of the movable arm so that it is pressed against the Lego screw.

Locate the front side of the front surface mirror (see above). Place the mirror on the intended location and fixate it with the T-link (E). During this step, it is important that the mirror is placed exactly as shown.

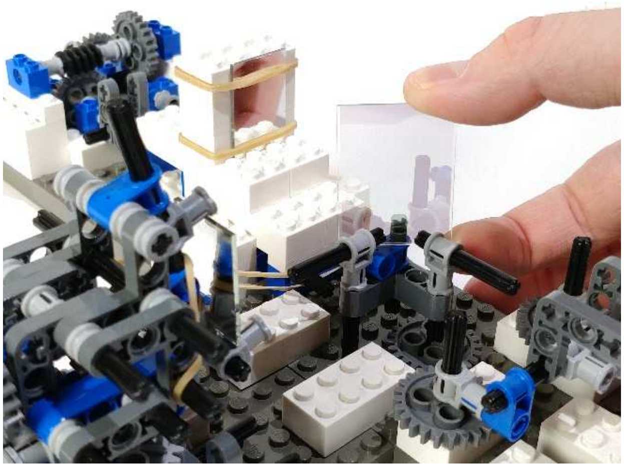


Adjust the mirror mount by using the two gears so that the mirror is perpendicular to the ground plate and parallel to the bobble pattern.

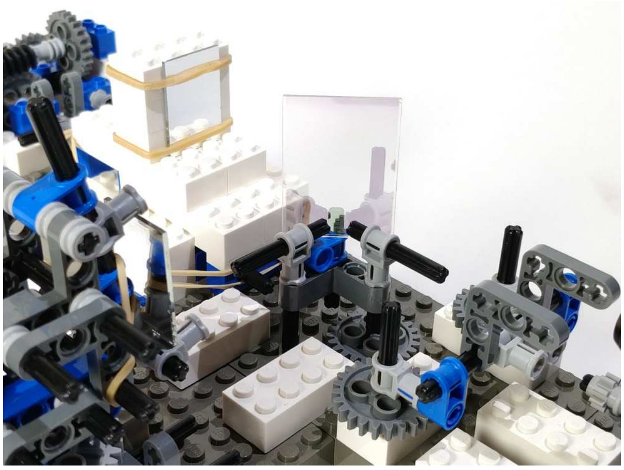


6. ADDING THE BEAMSPLITTER

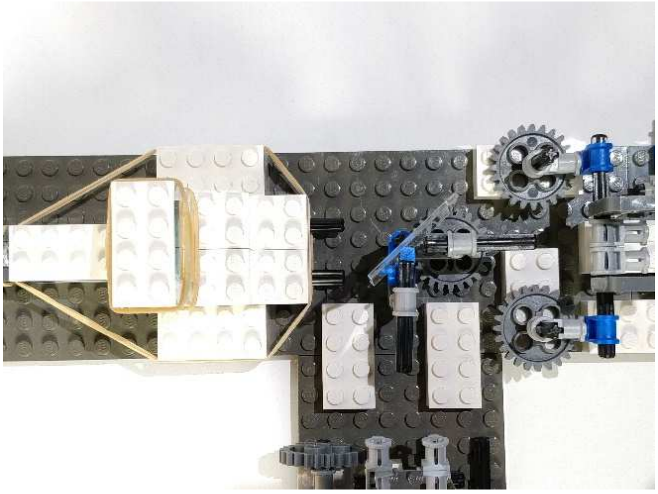
Hold the beam splitter at the intended place.



Fixate the beam splitter by pressing the two rods tot he splitter by using the T-link.

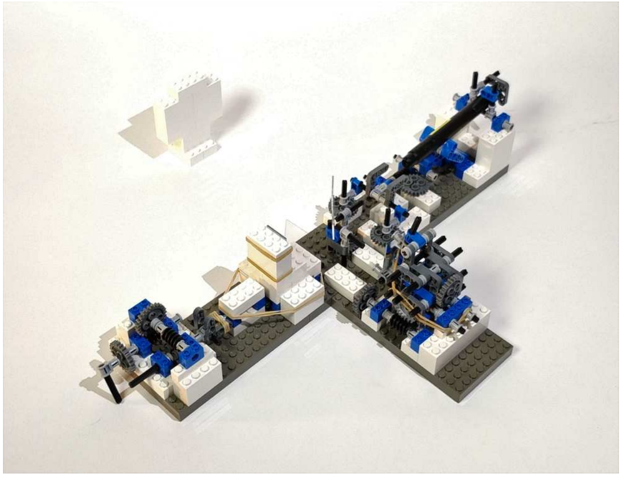


Adjust the beam splitter by light pusshing and pulling at the two rods. It should be in a 45° angle tot he bubble pattern rows on the ground plate.

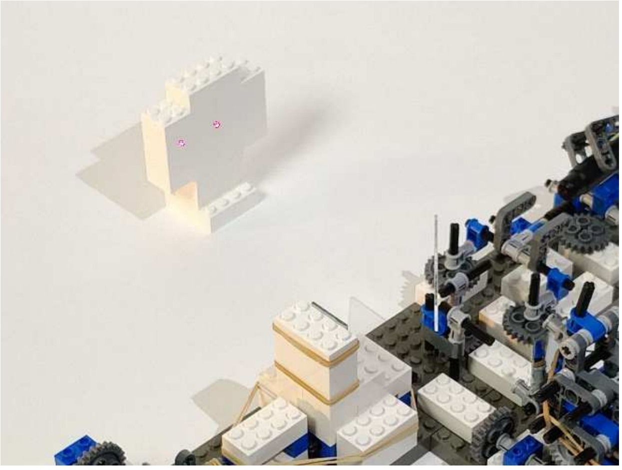


7. CALIBRATING CALIBRATABLE MIRROR

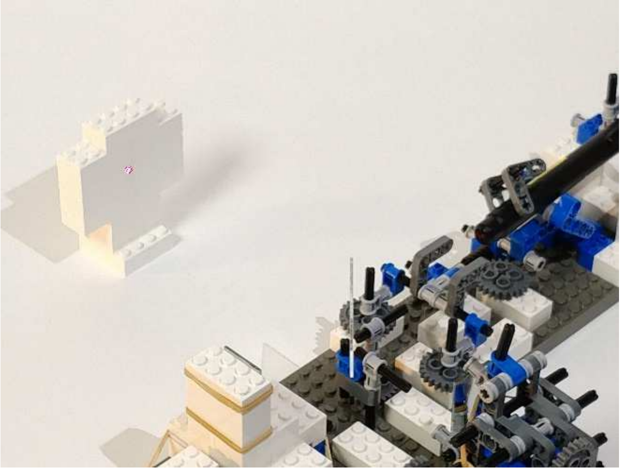
Place the screen at the position shown.



Switch on the laser pointer. There should be two points visible at the screen.



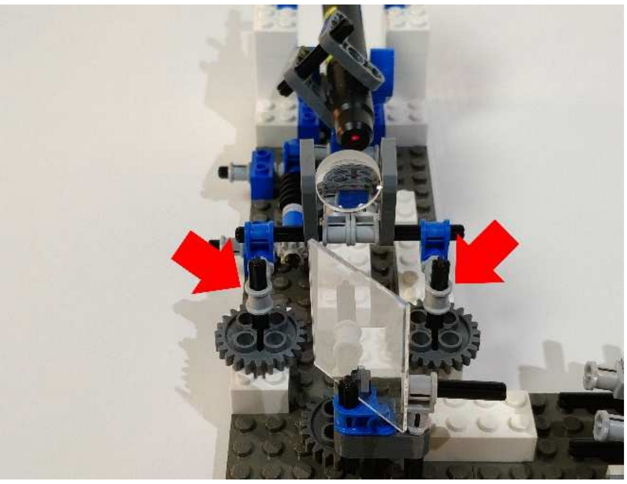
Adjust the calibratable mirror so that the two points are on top of each other.



Place the screen at a larger distance away from the construction and adjust the mirror, if two points are visible again.

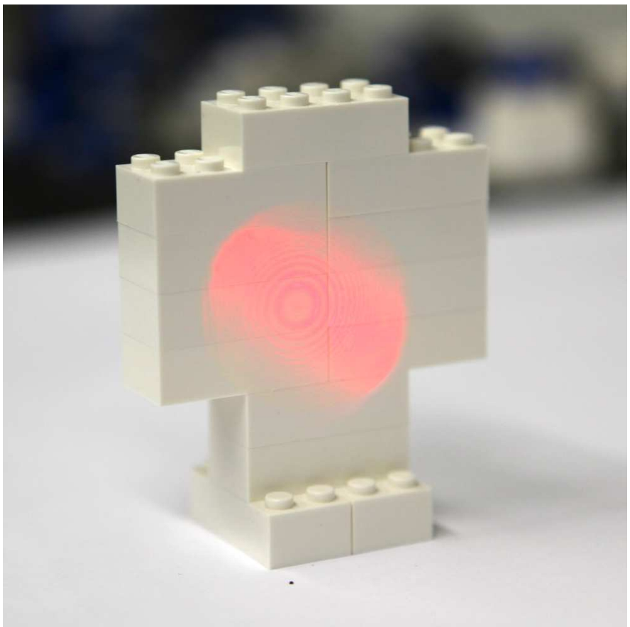
8. ADDING THE LENS

Hold the lens at the intended place and fixate it on both sides. Adjust the mount so that the beam hits the lens at its center. The height can be adjusted at the places marked by the red arrows.



FINE TUNING

There should now be an interference pattern on the screen. The center of the pattern can be shifted bei carefully adjusting the calibratable mirror mount and the lens.



TIPS AND POSSIBLE PROBLEMS

1. Should the front surface mirrors be placed at equal distances, the rings of the interference pattern might be too far apart and mostly not recognizable. In this case, it might help to take out the Lego-part with the screw and turn it for an additional one or two windings.
2. The interferomter is susceptible for all kinds of vibrations. Therefore, it is advised to place it on a stable surface. It might be helpful to use a clamp for fixating the interferometer to the table.
3. The stability can often be increased by making sure to press the bricks into each other whilst building the parts. This can be especially helpful at the links between the ground plates.

CALCULATING THE WAVELENGTH

To determine the wavelength of the laser, the gear is turned by the lever at the end of the transmission and the change of rings in the interference pattern is counted. The ration between rings and turns can be calculated by using the transmission ratio of the screws.

The transmission is constructed so that one full turn of the lever means

$\frac{1}{576}$ of a turn of the screw.

The screw has a pitch of 0,8mm. This means a shift of the sled by $\frac{1}{576} \cdot 0{,}8\ \text{mm} \approx 1{,}4\ \mu\text{m}$ per turn.

All in all, one can get the wavelength λ by using

$$\lambda = \frac{2 \cdot \Delta d}{N} = \frac{2 \cdot \frac{T}{576} \cdot 0{,}8\ \text{mm}}{N}.$$

Δd ist he distance that the sled travels, N the number of ring shifts and T the number of turns of the lever.