

E2 - Optical black-box (10 pts)

WARNING!

Do not open the black-box. Do not shake the black-box. Do not touch the windows of the optical ports. If you break the black-box or the windows or attempt to open the black box, you will be disqualified.

Your task is to determine the contents of an optical black box without opening it.

The black-box has four optical ports (A, B, C and D) for light, and two optical axes (Fig. 2). The optical axes are perpendicular to each other. There is up to one optical element behind each of the ports as well as another one in the center of the box. You can use a laser and a laser mount with a wheel (that you can put marks on it with a pencil) in order to rotate the laser.

Equipment (see also Fig. 4)

- A Black-box
- B Laser module in mount with wheel (the same laser module is used for both experiments, to be placed on the table surface)
- C Transparent block
- D Masking tape, pencil, ruler, paper with diagonal scale

Do not look directly into the laser beam, and make sure no other people are hit by it. Do not look into the optical ports of the box if the laser is on, and turn the laser off when not needed.

Task E2.1 - Central element (~0.3 pts)

The two optical axes cross in the center of the black box. At the crossing could sit: no element, a fully reflective mirror (both sides), a semi-transparent mirror, or a regular-triangle-shaped prism.

Table 1: Possible elements in the slots of the black-box

no element	there is just air in the slot
mirror	angle between the mirror axis and one of the optical axes
prism	angle between one of its sides and one of the optical axes of the black box, shaped like regular triangle
concave or convex lens	distance to the center of the box, magnitude and sign of the focal length. <i>Note: Axes of lenses are always along optical axes.</i>
polarizer	angle of orientation relative to the vertical axis of the black-box
single, thin slit	distance to the center of the box, width of the slit
diffraction grating	distance to the center of the box, direction of stripes, distance between the stripes
pin hole	distance to the center of the box, hole diameter

Determine which element is placed centrally in the black box. Describe its orientation towards the optical ports (A, B, C, D) - for example by using a sketch. Justify your choices.

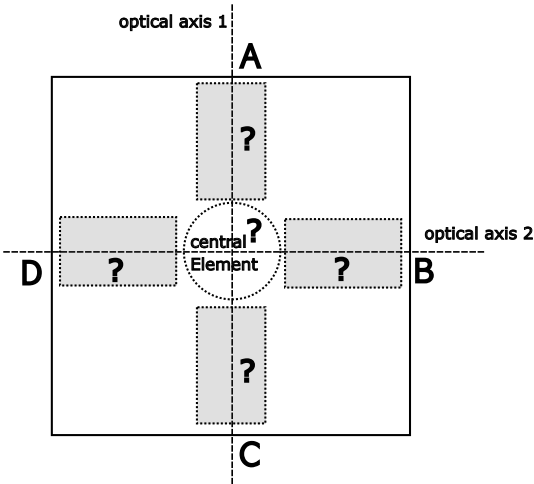


Figure 2: Layout of the black box and the slots of the unknown elements

Task E2.2 - Elements in remaining slots (~2.2 pts)

There is one element from Table 1 in each of the four slots behind the optical ports A, B, C, D, respectively.

Determine for each slot the type of element present. Justify your choices.

Task E2.3 - Properties (~7.5 pts)

In Table 1, you can find a second column containing characteristic properties of the possible elements.

Determine these characteristic properties for the optical elements used inside the box at slots A, B, C and D **as precisely as possible**.

Important hints:

- The wavelength of the laser is (650 ± 5) nm.
- The refractive index of transparent elements can be assumed to be 1.5.

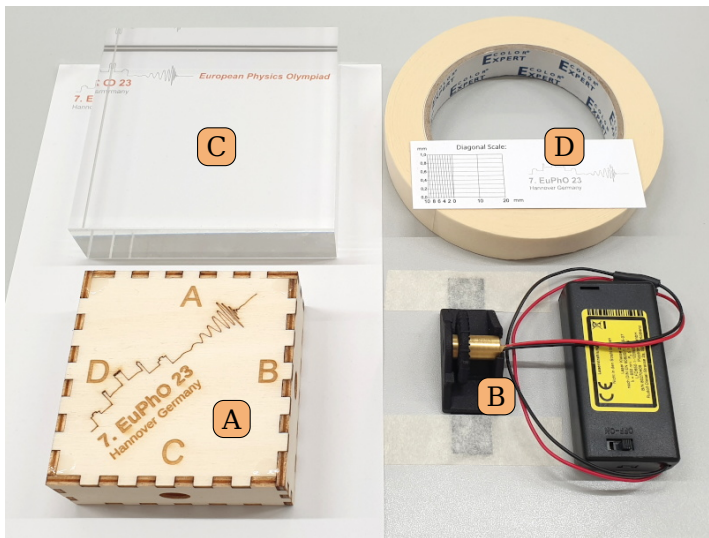


Figure 4: Setup and equipment for experimental problem E2. *Note: You can secure the laser module to the table using the tape - see B.*