Reflection of water waves at curved obstacles

Objects of the experiment

- Investigating the reflection of straight water waves at a convexly curved obstacle (reflector with convex curvature)
- Investigating the reflection of straight water waves at a concavely curved obstacle (reflector with concave curvature)

Principles

Water waves are reflected at obstacles. When straight waves are reflected by curved obstacles, the originally parallel wave rays travel in either convergent or divergent directions, depending on the curvature of the obstacle. In the process, each individual wave ray is reflected at an imaginary planar section of the obstacle according to the law of reflection (angle of incidence = angle of reflection).

Just as in optics, we can regard circularly curved obstacles as concave and convex reflectors. In the reflection in these “mirrors”, we can observe a focusing to a focal point, respectively a divergence from this focal point, just as in optics. The focal length is equal to one half the bending radius of the “mirror”.

To enable observation of reflection, straight waves are generated in the filled wave trough. As reflectors, we can use immersion bodies with the cross-sections of a biconvex lens as a convex reflector and a biconcave lens as a concave reflector; the bodies extend above the waterline.

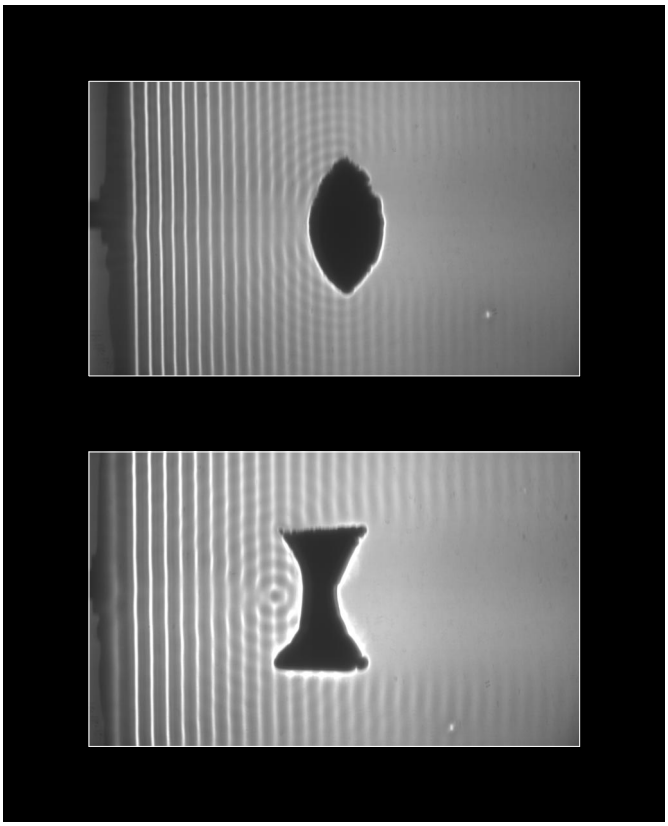

Fig. 1 Reflection of straight water waves at curved obstacles (photographs)
Top: reflection in a “convex mirror”
Bottom: reflection in a “concave mirror”

Apparatus

1 Wave trough with motor stroboscope . . . 401 501

additionally required:

Dish soap,
transparencies, transparency pens, adhesive tape

Setup

Set up the experiment as shown in Fig. 2.

– Set up the wave trough so that it is not subject to shocks and vibrations; observe all information given in the Instruction Sheet.
– Place the plastic biconvex lens in the middle of the wave trough and fill the trough with water; do not cover the lens completely with water (filling depth 5 mm).
– Connect the exciter for straight waves “parallel” to one of the convex sides of the lens at a distance of approx. 15 cm, as shown in Fig. 3.
– Attach a transparency to the observation screen **(g)** using adhesive tape.

Carrying out the experiment

a) Reflection of straight water waves at a “convex mirror”:

– If necessary, rotate the stroboscope disk out of the beam path using knurled screw **(f)** so that the glass pane in the bottom of the wave trough is completely illuminated.
– Using knob **(e)**, set a frequency from 20-30 Hz, and carefully increase the excitation amplitude using knob **(d)** until reflected wave fronts are clearly visible (see Instruction Sheet for wave trough).
– Vary the immersion depth of the exciter as necessary with adjusting screw **(h)**.
– Observe the shape of the reflected wave fronts.
– Switch on the stroboscope with switch **(a)**; after a short warm-up time, you may need to carry out a fine adjustment of the excitation and stroboscope frequencies using knob **(b)** until a stationary wave image appears.
– Draw the shapes of the incident and reflected waves on the transparency.
– Repeat the experiment with a wave packet. If necessary, rotate the stroboscope disk out of the beam path, turn amplitude knob **(d)** all the way to the left and press pushbutton **(c)** for single-wave excitation.

b) Reflection of straight water waves at a “concave mirror”:

– Replace the biconvex lens with the biconcave lens. Align one of the concave sides “parallel” to the exciter.
– If necessary, rotate the stroboscope disk out of the beam path using knurled screw **(f)** so that the glass pane in the bottom of the wave trough is completely illuminated.
– Use the exciter to generate straight waves. To do this, set a frequency from 20-30 Hz, and carefully increase the excitation amplitude until reflected wave fronts are clearly visible (see Instruction Sheet for wave trough).
– Vary the immersion depth of the exciter as necessary with adjusting screw **(h)**.
– Observe the shapes of the reflected wave fronts.
– Using the stroboscope, generate a stationary wave image.
– Draw the shape of the incident and reflected waves on the transparency. Mark the point at which the reflected waves circularly converge.
– Repeat the experiment with a wave packet.

Measuring example

Fig. 1 shows two photographs with measurement examples.

Results

a) Reflection of straight water waves at a “convex mirror”:

The convex reflector reflects the incident water waves as circular waves. The reflected circular waves appear to originate from a point-type exciter (focal point) behind the convex reflector (see Fig. 1).

b) Reflection of straight water waves at a “concave mirror”:

The concave reflector reflects the incident water waves as circular waves which converge at one point (the focal point); see Fig. 1.

In both cases, the curvature of the reflected wave fronts directly at the reflector is greater than the curvature of the reflector itself.

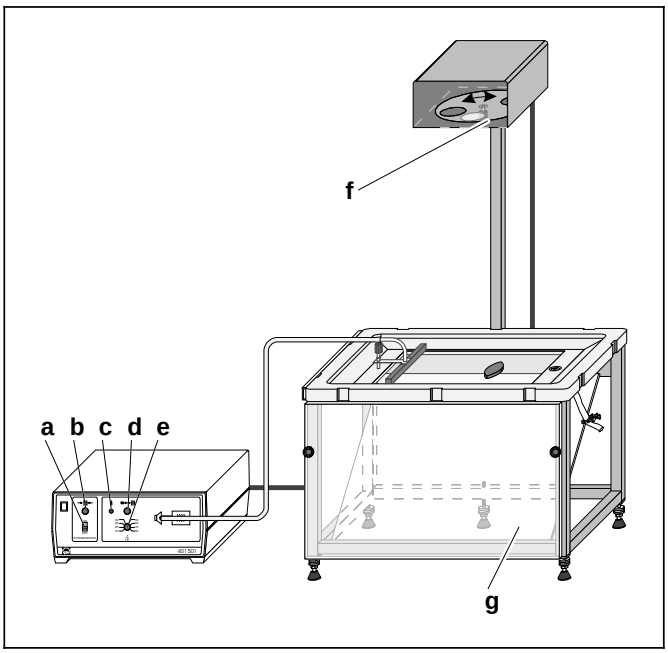

Fig. 2 Experiment setup for exciting circular waves
- **a** Stroboscope switch
- **b** Knob (for fine adjustment of stroboscope frequency)
- **c** Pushbutton (single-wave excitation)
- **d** Knob (for adjusting amplitude of wave excitation)
- **e** Knob (for adjusting frequency of wave excitation)
- **f** Knurled screw (for manually turning stroboscope disk)
- **g** Observation screen

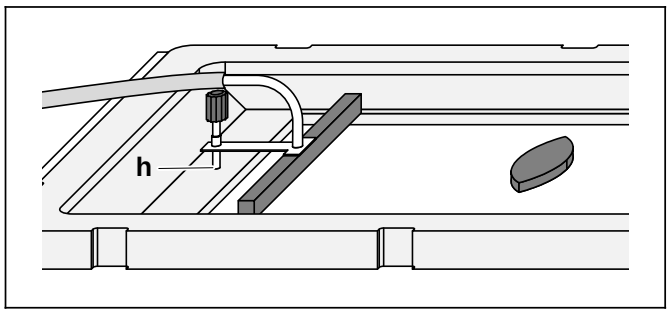

Fig. 3 Connecting the exciter for straight waves and setting up the convex lens as a “convex mirror”
- **h** Adjusting screw (for setting immersion depth)

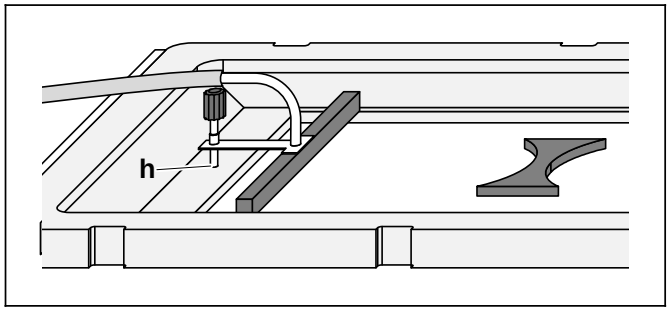

Fig. 4 Connecting the exciter for straight waves and setting up the concave lens as a “concave mirror”
- **h** Adjusting screw (for setting immersion depth)

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