

Huygens' principle in water waves

Objects of the experiment

- Observing the propagation of water waves behind an edge (change in the direction of propagation).
- Observing the propagation of water waves behind a narrow slit (creation of circular waves).
- Observing the propagation of water waves behind a grating (superposing of circular waves to form a straight wave).

Principles

Christiaan Huygens originated the following concepts for the propagation of waves.

First: Each point in a wave front can be considered the starting point of a "wavelet" or secondary wave, which propagates with the same velocity and wavelength of the original wave.

Second: The envelope of all wavelets is the new wave front.

To verify Huygens' principle, straight wave fronts are generated in the filled wave trough, which successively strike a straight obstacle with an edge, a narrow slit and a grating. We can observe a change in the direction of propagation behind the edge, the creation of circular waves behind the narrow slit and the superposing of circular waves to form one straight wave behind the grating.

The combination of Huygens' principle with the principle of interference for interpreting diffraction of water waves at a slit or grating, originating with *A. Fresnel*, is explained in the topic group "Interference with water waves".

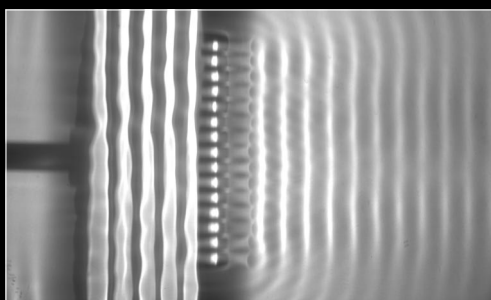
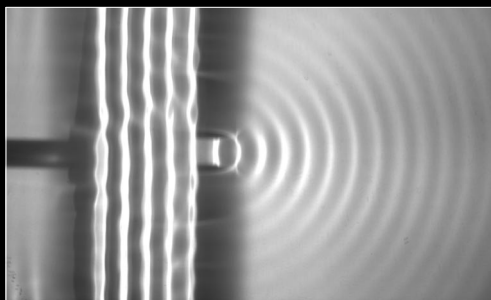
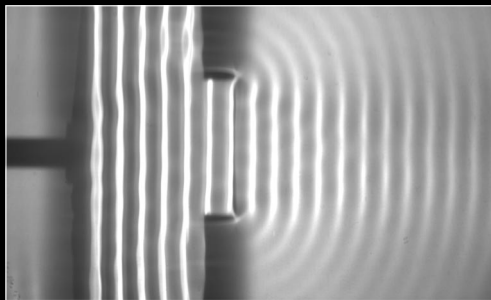


Fig. 1 Applying Huygens' principle to water waves (photographs)
Top: diffraction of straight waves at edges
Middle: generation of circular waves behind a narrow slit
Bottom: superposing of circular waves to form a straight wave

Apparatus

1 Wave trough with motor stroboscope 401 501

additionally required:

Dish soap

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.
- Connect the exciter for straight waves as shown in Fig. 3.

Carrying out the experiment**a) Propagation of water waves behind edges:**

- Place the obstacle with large slit (see Fig. 4, top) in the center of the wave trough precisely under the lamp. Set up the wave exciter parallel to the obstacle at a distance of approx. 10 cm.
- 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 of approx. 20 Hz, and carefully increase the excitation amplitude using knob **(d)** until wave fronts are clearly visible (see Instruction Sheet for wave trough).
- Vary the immersion depth as necessary with adjusting screw **(h)**.
- Observe the wave image behind the obstacle.
- To observe stationary wave images, 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.

b) Propagation of waves behind a narrow slit:

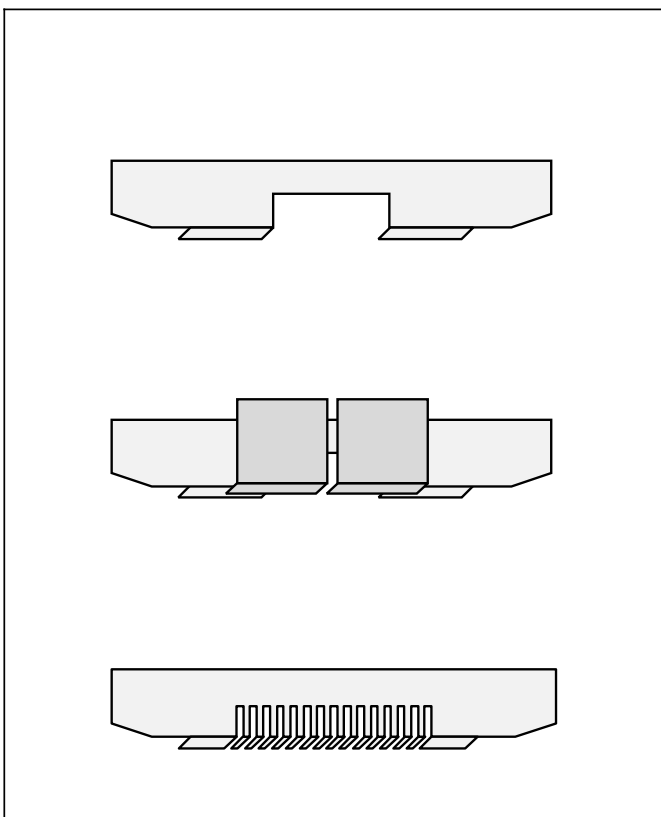
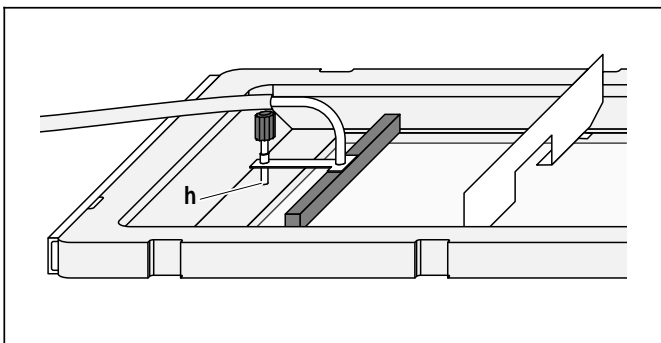
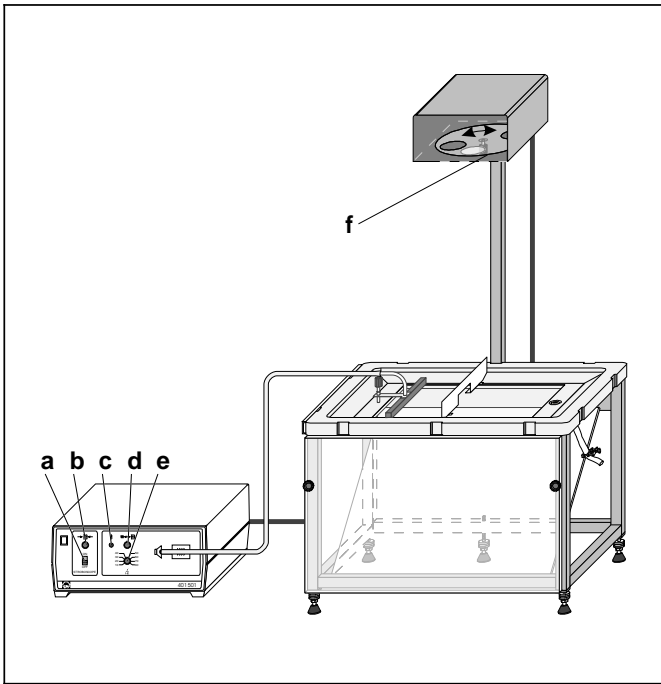
- Place the obstacle with large slit in the center of the wave trough precisely under the lamp. Use the two wide cover slides to reduce the large slit so that the slit width is less than the wavelength (see Fig. 4, middle). Set up the wave exciter parallel to the obstacle at a distance of approx. 10 cm.
- If necessary, rotate the stroboscope disk out of the beam path so that the glass pane in the bottom of the wave trough is completely illuminated.
- Set a frequency of approx. 20 Hz, and carefully increase the excitation amplitude until wave fronts are clearly visible.
- Vary the immersion depth as necessary.
- Observe the wave image behind the obstacle.
- Vary the frequency; if necessary, adjust the amplitude and observe the wave images behind the obstacle.
- Use the stroboscope to observe stationary wave images.

c) Propagation of waves behind a grating:

- Place the obstacle with 15 individual slits in the center of the wave trough precisely under the lamp (see Fig. 4, bottom). Set up the wave exciter parallel to the obstacle at a distance of approx. 10 cm.
- If necessary, rotate the stroboscope disk out of the beam path so that the glass pane in the bottom of the wave trough is completely illuminated.
- Set a frequency of approx. 20 Hz, and carefully increase the excitation amplitude until wave fronts are clearly visible.
- Vary the immersion depth as necessary.
- Observe the wave image behind the obstacle.
- Vary the frequency; if necessary, adjust the amplitude and observe the wave images behind the obstacle.
- Use the stroboscope to observe stationary wave images.

d) Propagation of a wave packet behind the obstacles:

- Set up one of each of the obstacle types as described above.
- If necessary, rotate the stroboscope disk out of the beam path and turn the amplitude knob all the way to the left. Make sure that the wave exciter just touches the surface of the water over its entire length.
- Actuate pushbutton **(c)** for generating single waves.
- Observe the image of the wave packet behind the obstacle.



Measuring example

Fig. 1 shows three photographs with measurement examples.

Results

a) Propagation of waves at an edge:

The waves behind the obstacle do not only propagate in their original direction. They also curve around into the “shadow” of the obstacles and penetrate this area in the form of circular waves (diffraction of waves at an edge).

It appears as though the edges were point-type excitation centers.

In the shadow zone, the waves are significantly weaker than in the linear-propagation zone. Long waves show diffraction at an edge more clearly than short waves.

b) Propagation of waves behind a narrow slit:

The waves behind the slit do not only propagate in their original direction. They propagate in all directions in the form of semicircular waves (diffraction of waves at a slit).

The narrower the slit is in relation to the wavelength, the more clearly visible this diffraction is.

It appears as though the slit were a point-type excitation center.

As we can set up the slit at any point of a wave running against an obstacle, then, according to Huygens’ first principle, each point of a wave front can be viewed as the origin of a new wave (wavelet).

c) Propagation of waves behind a grating:

Each slit of the grating generates a circular wave. We can consider these to be wavelets. The circular waves meet and superpose on each other. New wave fronts are formed. According to the second postulate of Huygens’ principle, we can consider the new wave front as the envelope of the wavelets.

Fig. 2 Experiment setup on Huygens’ principle

- 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)

Fig. 3 Connecting the exciter for straight waves

- h Adjusting screw (for setting immersion depth)

Fig. 4 Obstacles (viewed from exciter)

- Top: wide slit
- Middle: narrow slit
- Bottom: grating

