Dependency of propagation velocity on water depth

(Item No.: P1120401)

Curricular Relevance

Area of Expertise: Physik | **Education Level:** Klasse 10-13 | **Topic:** Mechanik | **Subtopic:** Schwingungen und Wellen | **Experiment:**

Difficulty

Intermediate

Preparation Time

10 Minutes

Execution Time

20 Minutes

Recommended Group Size

2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Introduction

Overview

Water waves propagate more slowly in an area with reduced water depth than in areas with greater water depth.

Material

From the accessory set 11260-12 (included in 11260-88):

Position No.	Material	Order No.	Quantity
1	Holder for plane wave generator		1
2	Plane wave generator		1
3	Refraction object, plane-parallel plate		1

Method

A rectangular acrylic glass plate is placed in the wave tank of the ripple tank. The filled height of the water is chosen so that the surface of the water is slightly above the acrylic glass plate. The wavelength is measured in the area of the deep water and in the area above the acrylic glass plate. The plane wave exciter (wave generator) frequency set at the ripple tank and the measured wavelength are used to determine the two different propagation velocities.

Set-up and procedure

Set-up

The plane wave exciter is fixed to the exciter arm and is moved to the bottom edge of the tank. The rec-tangular acrylic glass plate from the set of refraction objects is placed in the wave tray as shown in Fig. 1. The plate should be completely covered with water.

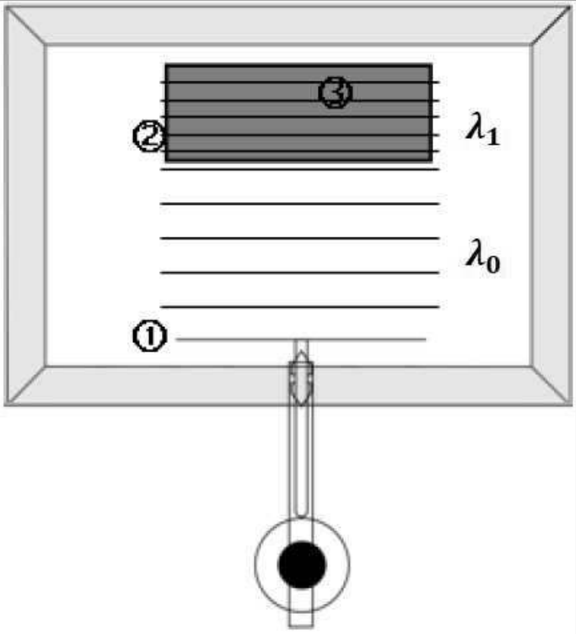

Figure 1: Experiment arrangement for demonstrating the dependency of propagation velocity on water depth. The wave front (1) produced by the planar wave generator with wavelength λ_0 continues to propagate above the rectangular plate (2) with a different wavelength λ_1 (3).

Procedure

After the wave generator and the wave tank have been carefully adjusted, an exciter frequency between 18 Hz and 25 Hz is set at the ripple tank and the exciter amplitude is set in such a way that a clear wave pattern results. The spray bottle is used to suck water out of the wave tank until a clear reduction in wavelength can be identified in the area above the rectangular plate. The plate must remain completely immersed in the water.
The stroboscopic lighting is then switched on to obtain a standing wave pattern ($\Delta f = 0$). A common ruler can now be used to measure the wavelength outside and within the area of the plate on the bench (Fig. 2).

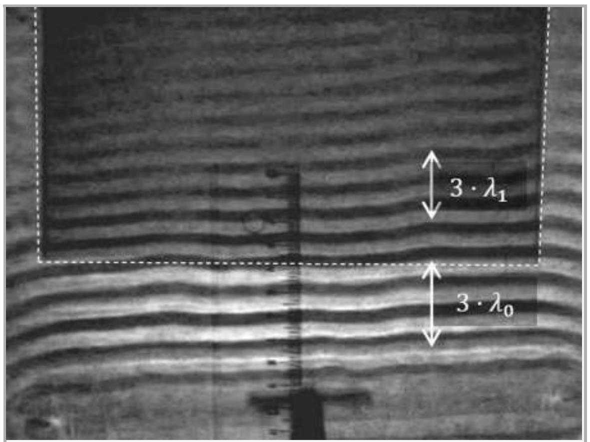

Figure 2: Instantaneous snapshot as shown in Fig. 1. A reduction in wavelength λ_1 above the plate (edge highlighted with broken line) can be clearly recognised. The number 3 gives the number n of wave trains between the respective measuring points.

To this end the distance between two wave crests as far apart as possible is measured and this meas-ured value is divided by the number n of wavelengths falling within this path interval.

The measured values together with the set frequency and the propagation velocity to be calculated ($c = f \cdot \lambda$) are entered in a table.

Note:

If measurements are taken on the drawing table, it must be noted that the actual wavelength can differ from the wavelength measured on the drawing table. This is because the optical conditions make the image on the bench appear larger. However, as relative changes in wavelength are involved here the re-sulting measurement error is the same for all measurements so that it can be ignored at the end.

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Evaluation and results

Results

The wavelength and thus the propagation velocity is smaller in shallow water than in deep water. A measurement example is given in the following table:

	f / Hz	$n \cdot \lambda$ / cm	n	λ / cm	c / cm/s
deep water	22	4.2	3.5	1.20	26.40
shallow water	22	3.6	3.5	1.03	22.63

Interpretation

At the interface between an area with a large water depth and an area with a very small water depth, the behaviour of water waves is analogous to that of light waves at the interface between air and glass. Just as the propagation velocity of light is lower in glass than in air, water waves in shallow water have a lower propagation velocity than in deep water. In this measurement example the crossover from deep to shallow water corresponds to a refractive index of 1.17 (ratio of propagation velocity in deep water to the propagation velocity in shallow water).

Note

Higher refractive indices can in principle also be achieved by further lowering of the water level. How-ever, the smaller the water depth the larger the attenuation of the waves so that ultimately they only penetrate a few centimetres into the shallow water zone. Precise observations and quantitative measurements are then no longer possible. The behaviour of shallow water zones is analog to the behaviour of glasses with high absorption. The refraction of water waves can therefore never be demonstrated without large absorption losses.