

# Diffraction and Interference of Microwaves



P2460903

Physics

Mechanics

Vibrations &amp; waves



Difficulty level

-



Group size

-



Preparation time

-



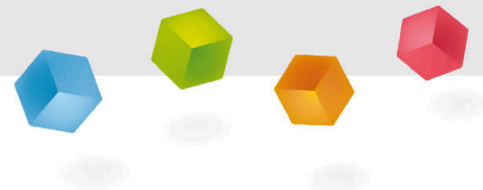
Execution time

-

This content can also be found online at:

<http://localhost:1337/c/60585c4bb622c60003db4641>

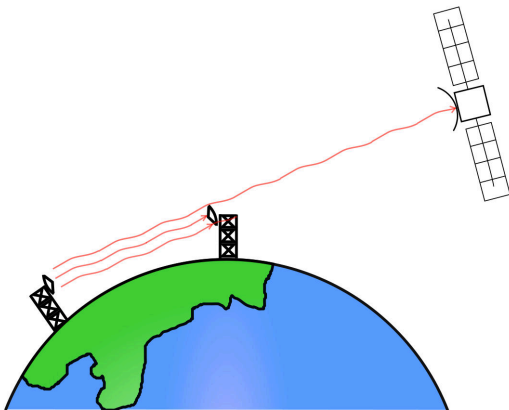
PHYWE



## General information

### Application

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Satellite communications

Microwaves are widely applied in communications due to its high frequencies. They can be used to transmit signals over large distances if the transmitter and receiver are in line of sight or if there are no obstacles in between. They are also used in satellite communications as they can pass through ionosphere without significant attenuation.

## Other information (1/2)

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### Prior knowledge



The prior knowledge required for this experiment is found in the theory section.

### Scientific principle



When a wave reaches an obstacle, in which a slit slightly wider than the wavelength is made, the phenomenon of diffraction occurs. When the obstacle has two slits, the radiation diffracted by each of them will interfere with each other.

## Other information (2/2)

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### Learning objective



Understanding diffraction of microwaves through single and double slits.

### Tasks



First, familiarise yourself with the phenomenon of diffraction through a single-slit. Then, perform the experiment with the doubleslit (Young's experiment) to observe the different phenomena occurring compared to the single-slit.

## Safety instructions

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For this experiment the general instructions for safe experimentation in science lessons apply.

For H- and P-phrases please consult the safety data sheet of the respective chemical.

During the experiment, do not stand in the direct vicinity of the beam path. The human body reflects microwaves so that the measurement result may be invalidated. The same applies to all types of metallic objects. If several experiments are performed simultaneously in a laboratory, ensure sufficient distance between the experiment stations in order to avoid interference signals caused by reflected radiation and/or scattered radiation from the other set-ups. Stay in the direct vicinity of the set-up only for adjusting the angle.

## Theory (1/3)

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### *Diffraction through a single slit*

During the diffraction through a (single) slit in the first experiment, for example, the microwaves are diffracted into an angle (or angular range) so that, when the slit is removed from the beam path, the intensity under the same angle is lower than before.

When a wave reaches an obstacle, in which a slit slightly wider than the wavelength is made, the phenomenon of diffraction occurs. Beyond the slit, the energy does not spread uniformly, but presents maximum points alternating with minimum points.

This strange distribution is explained by the Huygens-Fresnel principle according to which all the points of the slit, belonging to the same wave front, behave like coherent wave sources, so in a generic point of space, beyond the slit, the intensity will be the result of the overlapping of these elemental waves. Beyond the screen there will be an alternation of maximum intensity points with minimum intensity points

## Theory (2/3)

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In the central position the intensity is maximum, but moving the receiver slowly, a sequence of minimums and maximums is detected.

It can be shown that the angular distance between the central maximum and the first minimum satisfies the following relationship:

$$\sin \alpha = \pm \frac{\lambda}{d} \quad (1)$$

where  $\alpha$  is the displacement angle of the receiver,  $\lambda$  is the wavelength,  $d$  and is the width of the slit.

## Theory (3/3)

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### *Diffraction of microwaves due to two slits (Young's experiment)*

When using the two slits grating metal sheet, the radiation diffracted by each of them will interfere with each other. This is Young's experiment.

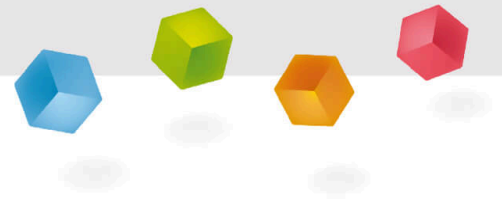
If  $a$  is the distance between the two slits, the first order maxima of the interference figure are given by the following relation:

$$\sin \alpha = \pm \frac{\lambda}{a} \quad (2)$$

## Equipment

Position	Material	Item No.	Quantity
1	Microwave set II, 110...240 V	11743-99	1

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## Setup and procedure

### Setup (1/3)

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Set the experiment up as shown in the figure.

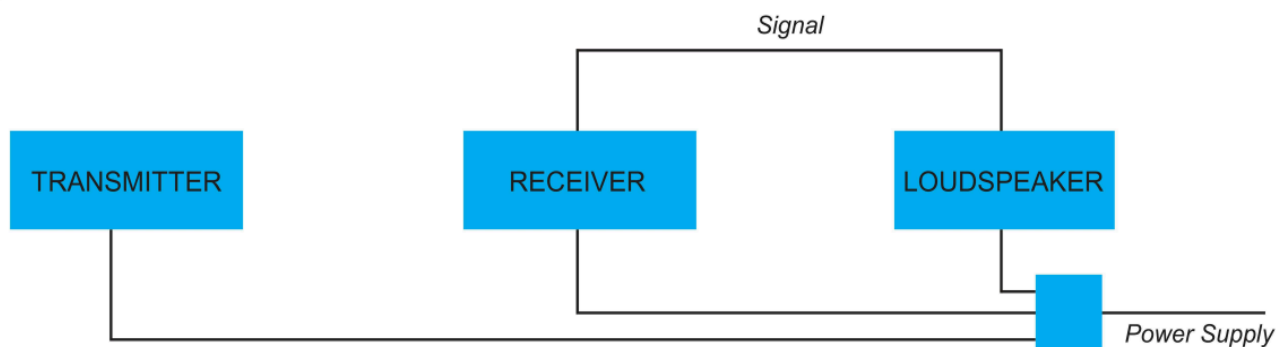


Single-slit in the microwave beam

## Setup (2/3)

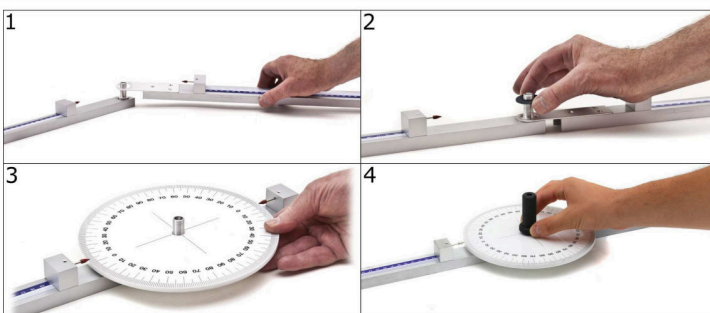
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Connect the microwave transmitter, receiver, and loudspeaker to the power supply via the three ways cable, and connect the receiver and the loudspeaker with the receiver - loudspeaker connection cable.



## Setup (3/3)

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Set-up of rail

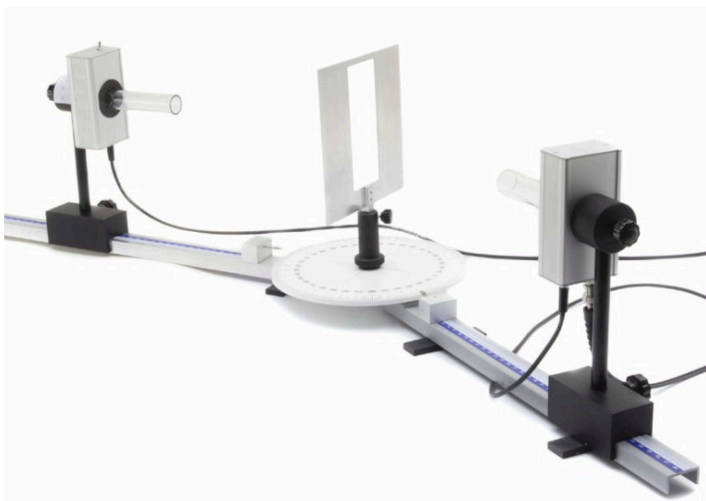
To assemble the articulated track with protractor, (1) first hook the short arm (having connection flange) to the long one (having pivot). (2) Then put the washer in the pivot. (3) Insert the protractor on the pivot at  $0^\circ$ , and (4) screw the black PVC yoke onto the pin.

Position the transmitter and the receiver both 25-30 cm away from the centre of rotation of the rail.



## Procedure (1/2)

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Diffraction through a slit

### *Diffraction through a single slit*

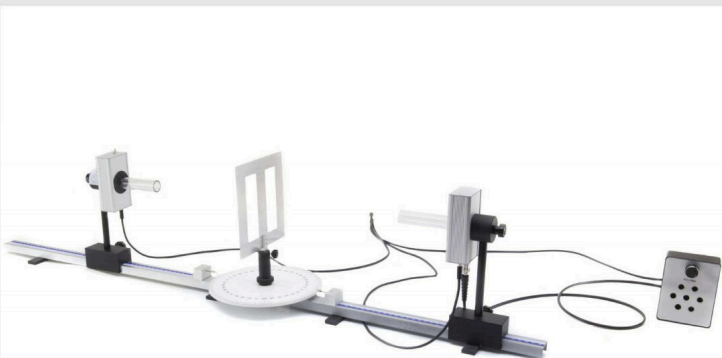
Plug in the power supply.

Turn the volume knob on the loudspeaker fully to the right. Note the signal during this initial set-up.

Then start to rotate the receiver slowly as shown in the figure. Try to determine the angle of the receiver position where the signal reaches a minimum intensity compared to the original set-up.

## Procedure (2/2)

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Set-up using two slits grating

### *Diffraction of microwaves due to two slits (Young's experiment)*

First, set the transmitter and receiver in the positions indicated in the figure and then replace the single slit grating with the two slits grating. The radiation diffracted by each of them will interfere with each other. The purpose of this experiment is to understand this interaction.

Take note of the signal with this set-up.

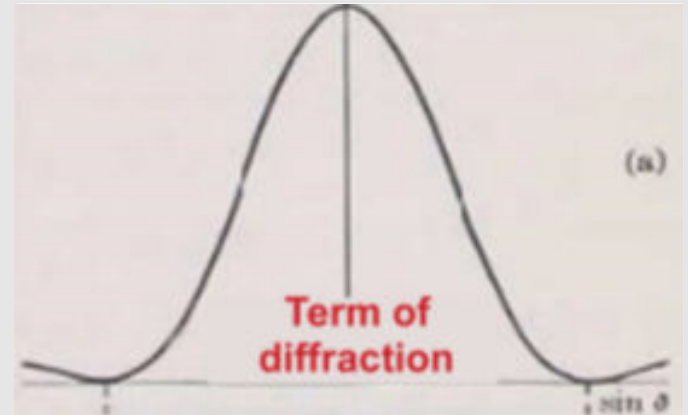
By rotating the receiver, it is possible to study the result of this overlap for different angles.

## Evaluation (1/3)

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### *Diffraction through a single slit*

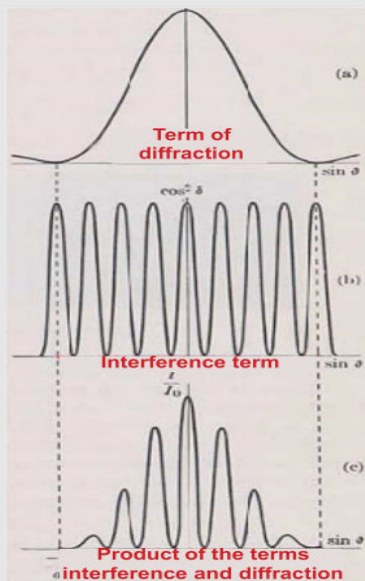
Being  $\lambda = 2.85 \text{ cm}$  and  $d = 5 \text{ cm}$ , the first minimum must be at the angle of rotation of the receiver of about  $34^\circ$ . You can verify this by gently adjusting the amplitude of the signal to cancel possible reflected signals



Intensity profile for single slit diffraction

## Evaluation (2/3)

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### *Diffraction of microwaves due to two slits (Young's experiment)*

The effect obtained in this case is a superposition of two phenomena: the interference between the elemental waves produced by the two slits and the diffraction obtained from each of the two slits.

In this situation the received signal is maximum, as the two elementary waves travel the same distance.

## Evaluation (3/3)

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If the slit is removed from the beam path during the diffraction through a slit at an angle, the intensity under the same angle will be:

- ☐ not change
- ☐ higher than before.
- ☐ lower than before.

☒ Check

If the gap between two slits is reduced, the distance between two maxima will:

- ☐ increase
- ☐ decrease

☒ Check

Slide

Score/Total

Slide 18: Multiple tasks

0/2

Total Score

 0/2 Show solutions Retry