Learning unit on the subject of microwaves

Physics | Electricity & Magnetism | Electromagnetic oscillations & waves

Difficulty level	Group size	Preparation time	Execution time
-	-	-	45+ minutes

This content can also be found online at:

http://localhost:1337/c/64df63207650380002833881

General information

Application

In meteorology, microwave radar systems, often called weather radar, are used to detect precipitation and its intensity. The radar emits microwaves that are reflected by raindrops, snowflakes or other atmospheric particles. By analysing the returning signals, meteorologists can determine the type, intensity and movement of precipitation. This helps in predicting weather phenomena such as storms, rainfall or snowfall. Weather radars are therefore essential tools for accurate and timely weather forecasts.

Modern radar technology allows precipitation to be predicted to the minute.

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Other information (1/3)

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Prior knowledge

The required prior knowledge can be found in the theory section.

Principle

Microwaves are electromagnetic waves with a wavelength typically between one millimetre and one metre. They can be absorbed, reflected, refracted and diffracted.

Other information (2/3)

PHYWE

Learning objective

The students should get an overview of the different properties of microwaves and investigate how microwaves behave on different materials.

Tasks

1. Check the function of the microwave transmitter and receiver.
2. Investigate the transmission and absorption of microwaves on various bodies.
3. Investigate the reflection of microwaves.
4. Investigate the refraction of microwaves.

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Other information (3/3)

Tasks

- Investigate the total reflection of microwaves.
- Investigate the polarisation of microwaves.
- Determine the plane of polarisation of microwaves.
- Investigate the diffraction of microwaves.

Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

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Theory (1/14)

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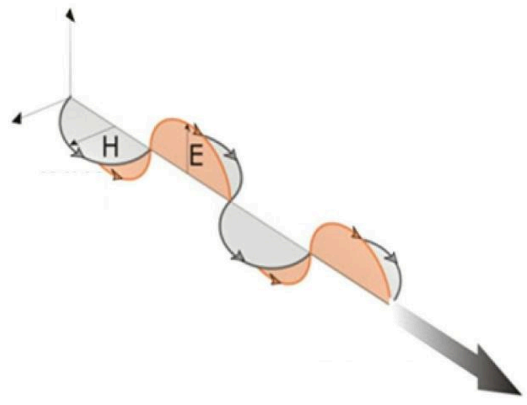
1. general information about electromagnetic waves

A monochromatic electromagnetic wave (i.e. with a fixed frequency and wavelength) consists of an electric field $\vec{E}$ and a magnetic field $\vec{B}$ resp. $\vec{H}$which are perpendicular to each other and perpendicular to the direction of propagation of the wave. A wave of this type is typically called a polarised plane wave. The plane of polarisation is the plane in which the electric field oscillates.



Representation of an electromagnetic wave:
$\vec{H} \perp \vec{E} \perp$ *Direction of propagation*

Theory (2/14)

PHYWE

Energetically, the electromagnetic wave can be compared to a flow of energy that propagates in a vacuum at the speed of light, in the form of electric and magnetic fields, in a straight line (in a homogeneous medium).

2. speed of electromagnetic waves in vacuum

The velocity of electromagnetic waves in a vacuum is a fundamental quantity in physics and is usually expressed by c is designated. Its numerical value is approx. $300.000 km/s$.

The light emitted by stars travels through the universe at the speed of light.

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Theory (3/14)

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3. speed of electromagnetic waves in the medium

The speed of electromagnetic waves in a homogeneous non-electric and non-ferromagnetic medium is lower than that in a vacuum: $v = \frac{c}{n}$, whereby n is the so-called refractive index.

The higher the refractive index, the lower the speed of propagation. The refractive index normally has a value > 1 and depends on the properties of the medium. The value of the refractive index also varies with the change in wave frequency.

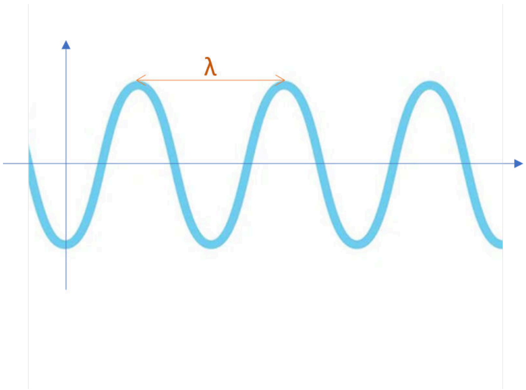
The speed of electromagnetic waves in different media depends on the refractive index of the respective medium.

Theory (4/14)

PHYWE

5. wavelength

The wavelength is the distance the wave travels in the time of a cycle (period). Graphically, it corresponds to the distance between a point in the cycle and the corresponding point in the next cycle (e.g. between two maxima). The wavelength is indicated by the Greek letter λ designated.



The shaft length λ is the distance between two identical points of two consecutive cycles.

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Theory (5/14)

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6. frequency

The frequency f describes how often a process or an event takes place in a certain period of time. In the case of waves, for example light waves or microwaves, the frequency indicates how often the wave oscillates in one second. It is measured in Hertz (Hz), where $1Hz$ means that one event or oscillation takes place per second.

The frequency and the wavelength are related to each other via the speed of light. The following applies:

$c = \lambda \cdot f$ in vacuum and

$\frac{c}{n} = \lambda \cdot f$ in the medium.

The following can be deduced from this:

1. At higher frequencies and constant speed, you have smaller wavelengths.
2. At a fixed frequency, the wavelength depends on the medium with a different refractive index.

Theory (6/14)

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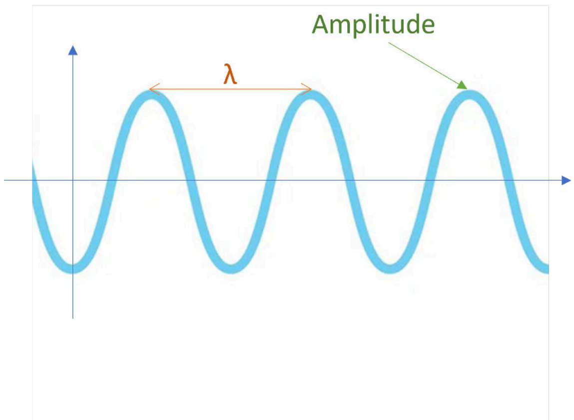
7. amplitude

The amplitude of a wave describes the maximum deflection of the wave from its rest position. In other words, it is the distance from the peak or trough of the wave to its centre line or initial level. For a sound wave, for example, the amplitude corresponds to the air pressure maximum, and it is directly related to the loudness of the sound. For an electromagnetic wave, such as light, the amplitude is related to the intensity or strength of the electromagnetic field. The amplitudes of the electric and magnetic fields are not independent but linked: electric and magnetic fields are coupled.



The amplitude of a wave describes the maximum deflection of the wave from its neutral position

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Theory (7/14)

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8. intensity

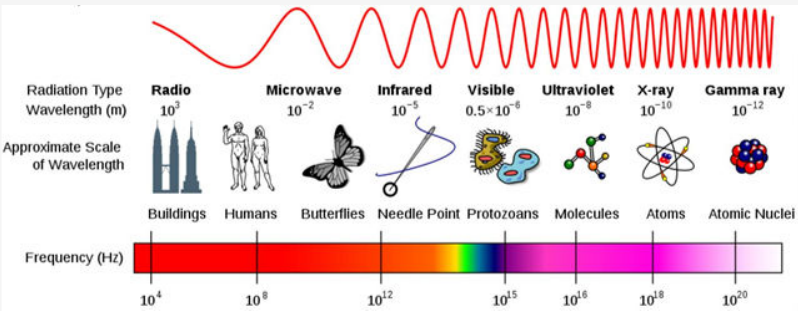
The intensity of an electromagnetic wave describes the amount of energy that passes through per second and per unit area (e.g. square centimetre or square metre) perpendicular to the direction of propagation of the wave. It thus indicates the strength or "power density" of the wave. The intensity is proportional to the square of the amplitude of the electric or magnetic field of the wave. With light, for example, the intensity corresponds to the brightness or luminosity. A higher intensity means that more energy is transported, and vice versa. The intensity I is usually measured in W/m^2.

The brighter a lamp shines, the greater its intensity.

Theory (8/14)

9. spectrum electromagnetic waves

The electromagnetic spectrum includes all types of electromagnetic waves, ordered by their frequency or wavelength. It ranges from very short gamma rays to the longest radio waves. In between are X-rays, ultraviolet rays, visible light, infrared rays and microwaves. Each part of the spectrum has its own characteristic properties and applications, from medical imaging with X-rays to communication with radio waves.



Overview of the electromagnetic spectrum.

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Theory (9/14)

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10. microwaves

Microwaves lie in the spectrum between infrared rays and the shorter radio waves. They have wavelengths in the range of about 1 millimetre to 30 centimetres and are commonly used in technologies such as mobile phone communication, radar and satellite systems, as well as in microwave ovens for heating food.

A microwave heats food by emitting microwaves that excite water molecules in the food and generate heat through friction.

Theory (10/14)

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Warning symbol against non-ionising radiation

10. dangers of microwaves

Whether microwaves are dangerous depends on the intensity, duration of exposure and the specific context of use:

1. **Microwave ovens:** These are designed to keep the microwaves inside the appliance. If a microwave oven is working correctly and has no damage, the risk to the user from microwave radiation is very low.
2. **Mobile communication:** Mobile phones use microwaves to communicate. The radiation emitted by mobile phones is generally low, and current scientific evidence is inconclusive about health risks from normal mobile phone use.

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Theory (11/14)

Warning symbol against non-ionising radiation

3. direct exposure: A high dose of microwaves can heat body tissues, similar to a microwave oven. This can cause burns or other injuries, especially if large areas of the body or sensitive organs such as the eyes are affected.

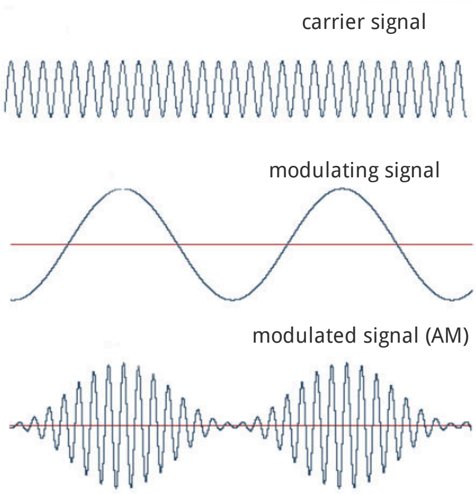
4. long-term, high-intensity exposure: Although the scientific consensus is that low to moderate exposures to microwaves are safe, long-term or high-intensity exposures can lead to health risks. Some studies suggest potential biological effects, but the results are not consistent and need further investigation.

It is always important to be aware of the specific source and intensity of microwave radiation and to follow safety guidelines. When used correctly and in compliance with safety standards, microwave applications in everyday life are generally safe.

Theory (12/14)

11. amplitude modulation

Amplitude modulation (AM) is a process in which the amplitude of a carrier wave is varied to transmit information, typically speech or music. The signal to be transmitted modulates the amplitude of the carrier wave, causing the total wave to represent the information of the signal. Here, the amplitude of the carrier signal varies proportionally to the amplitude of the modulating signal. Accordingly, the modulated signal (AM) has the same frequency as the carrier signal, while its amplitude is maximum at the maxima of the modulating signal and minimum at the minima of the modulating signal.



Amplitude modulation

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Theory (13/14)

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Drag the words into the correct boxes!

Electromagnetic waves propagate at a constant speed known as the ______. As a rule, the greater the frequency of a wave, the smaller its ______. The full spectrum of these radiations ranges from radio waves with very long wavelengths to gamma rays with very short wavelengths. The ______ of these waves determines how often they oscillate in one second. The magnetic field vector perpendicular to the electric field vector and the direction of propagation of the wave.

- speed of light
- frequency
- wavelength

Check

Theory (14/14)

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Which of the following statements about microwaves is correct?

- ○ Microwave ovens use infrared radiation to heat food.
- ○ Microwaves can heat metal and produce sparks.
- ○ Microwaves raise the temperature of food by directly heating the fats and sugars.
- ○ Microwaves are visible light rays with high intensity.

Check

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Equipment

Position	Equipment	Item no.	Quantity
1	Microwave set II	11743-99	1

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Setup, procedure and evaluation

Setup (1/6)

The microwave experiment set consists of a transmitter, a receiver, a loudspeaker, an articulated rail and other components.

Various experiments can be carried out on microwaves. For example, the analogy to light waves can be shown by investigating phenomena such as reflection, refraction, interference and diffraction.

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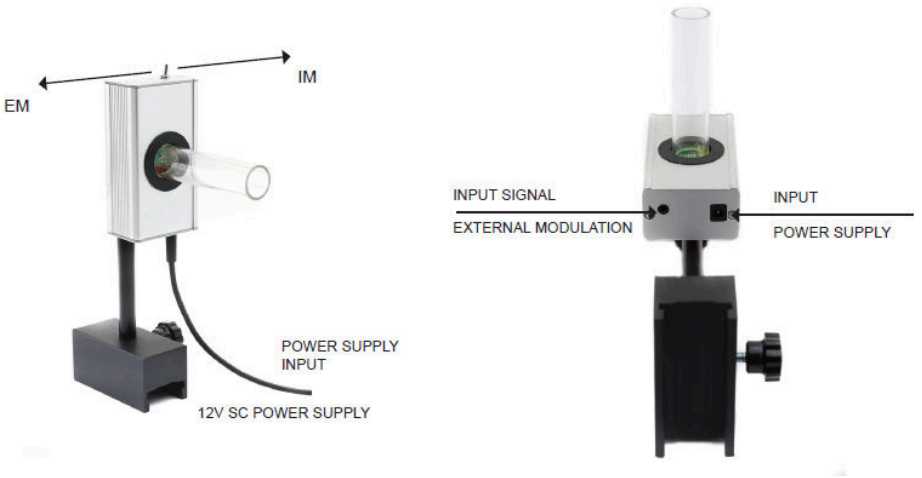
Setup (2/6)

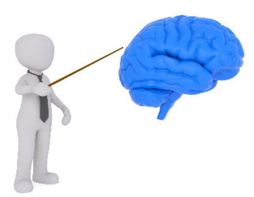
1. transmitter

With the toggle switch on the top of the transmitter, the carrier wave can be modulated either with the internal signal (IM) or with an external signal (EM). The input of the power supply and the input of the external modulation signal are located on the bottom of the transmitter.



Overview of the transmitter unit

Setup (3/6)



Technical data of the transmitting unit:

- Power supply: $12VDC$
- Frequency of the carrier wave: $f_T = 10,5GHz$
- Wavelength of the carrier wave: $\lambda = 2,85cm$
- Shape of the internal modulating signal: square wave
- Frequency of the internal modulating signal: $f_M = 550Hz$
- Maximum permissible amplitude for the external modulating signal: $2,5V$

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Setup (4/6)

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2. receiver

The receiver is shown in the adjacent illustration.

The BNC socket, located in the lower part of the receiving unit (see arrow), enables transmission of the receiving signal to a loudspeaker or to a detector instrument (e.g. push-button or oscilloscope).

Note that the operating distance between the transmitting and receiving units should be between $0m$ and $1,5m$.

Overview of the receiver unit

Set-up (5/6)

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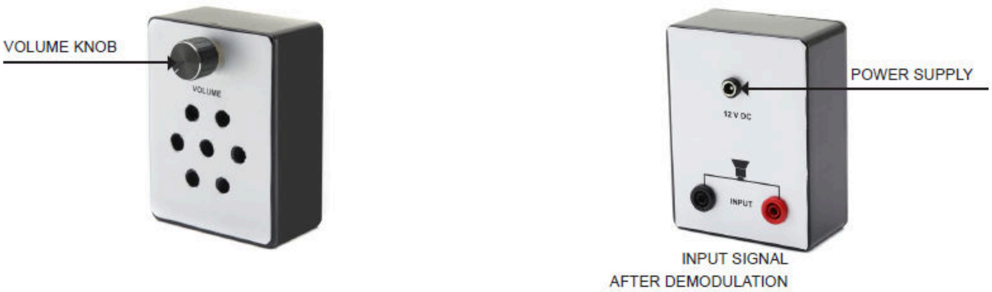
3. loudspeaker

The loudspeaker converts the signal received after demodulation by the receiver into an acoustic signal. After the signal has reached the loudspeaker from the receiver, it is amplified by the integrated amplifier. The amplitude of the amplification can be adjusted using the rotary control on the loudspeaker.



Overview of the speaker

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Set-up (6/6)

4. mounting the bench

- Hook the short arm (with connecting flange) to the long arm (with pivot point).
- Insert the metal disc into the pivot point.
- Set the protractor on the pivot point at 0° and finally screw the black PVC yoke onto the pin.
- At the end of assembly, it must be possible to twist the right arm independently of the left arm.

Experiment 1 - Procedure (1/1)

Experiment 1: Function test

- Set up the experiment according to the illustration and align the receiving unit with the transmitting unit. Select the internal modulation of the transmitting unit.
- Turn the volume control of the speaker all the way to the left and connect the power supply. Then slowly turn up the volume control. As the volume increases, you should hear a frequency tone of $550 Hz$ become audible.
- Investigate the influence of the human body on the measurement, e.g. by holding the hand in front of the receiver.

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Experiment 1 - Evaluation (1/1)

Which statements are correct?

- [ ] The signal is disturbed by the interaction with the human body.
- [ ] The surroundings of the superstructure should be as free as possible from other objects.
- [ ] It is useful to stand as close as possible to the set-up during the measurement so that you can clearly hear the change in the signal.
- [ ] The body is able to reflect and absorb microwaves.

Check

Experiment 2 - Theory (1/2)

Experiment 2: Transmission and absorption of microwaves through a polystyrene plate

The absorption and transmission of microwaves provides important qualitative information about the physical properties of substances that interact with electromagnetic waves. Let us now look at absorption:

When penetrating a medium with the thickness x it is observed that the following applies to the intensity of the transmitted radiation:

$I = I_0 \cdot e^{-kx}$,

where k is the absorption coefficient of the material at a known frequency. This relationship is also known as Lambert's law. If a material has the value $k = 0$ no absorption takes place. It can happen that a material is transparent for certain frequencies and absorbent for others.

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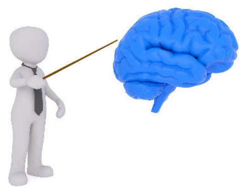
Experiment 2 - Theory (2/2)

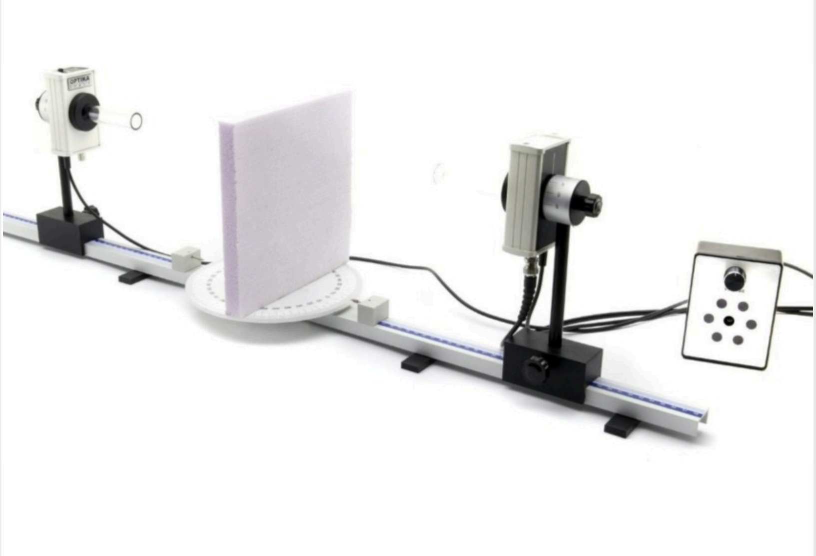
Microwave radiation is absorbed by various substances, whereby the absorption capacity depends on the chemical structure and the water content of the material. Here are some substances and materials that absorb microwave radiation:

1. Water
2. Certain ceramic materials
3. Tissues and biological materials
4. Some plastics containing water or absorbent materials

It is important to note that metals reflect microwaves and do not absorb them. This is why metal objects in a microwave oven can produce sparks and why the inner walls of microwave ovens are often coated with metal - to keep the microwaves inside the appliance.



Experiment 2 - Procedure (1/1)



- Set up the experiment according to the illustration, the polystyrene plate is not inserted at first. The transmitter and receiver are approx. $25cm - 30cm$ away from the pivot point.
- Turn the volume control slightly to the right to get a sound that can be heard at a distance of a few metres.
- Now place the polystyrene plate in the middle of the arrangement and observe the change in volume.

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Experiment 2 - Evaluation (1/2)

How does the volume change when a polystyrene panel is integrated into the setup?

- The sound gets louder.
- The volume remains the same.
- The sound becomes quieter.

What follows from the observations?

- A polystyrene sheet absorbs microwaves completely.
- A polystyrene sheet does not absorb microwaves. It is "transparent" for microwaves.
- A polystyrene plate absorbs and transmits part of the microwaves.

Check

Experiment 2 - Evaluation (2/2)

What is Lambert's law (law of absorption)?

- $I = (1 - I_0) \cdot e^{k \cdot x}$
- $I = I_0 \cdot e^{k \cdot x}$
- $I = I_0 \cdot e^{-k \cdot x}$

When media have a value of $k = 0$ no absorption takes place. Accordingly, the polysytrol plate has a value of $k > 0$

- True
- False

Check

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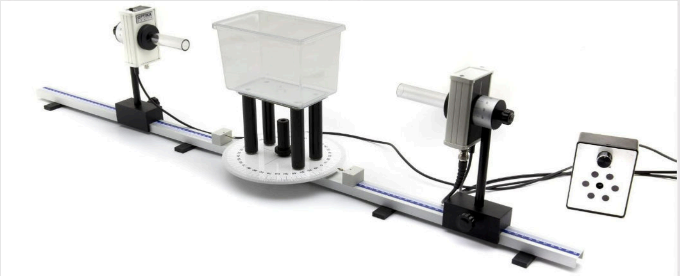
Experiment 3 - Procedure (1/1)

Experiment 3: Transmission and absorption of microwaves through water

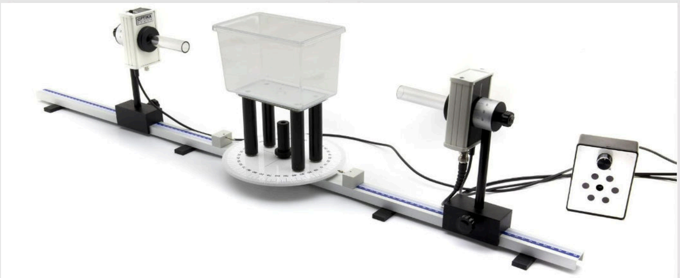
- Set up the experiment according to the illustration. At first, the water basin is empty.
- What can be observed? How does the sound change?
- Now fill the water basin with water.
- How does the sound change now?



Experiment 3 - Evaluation (1/2)

How does the volume change when the unfilled basin is integrated into the structure?

- The sound becomes quieter.
- The sound gets louder.
- The volume remains the same.



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Experiment 3 - Evaluation (2/2)

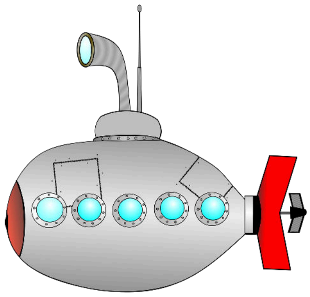
How does the volume change when the pool is now filled with water?

- The sound gets louder.
- There is no sound at all.
- The sound becomes quieter.
- The volume remains the same.

For this reason, it is important that submarines and boats use a sonar system (based on sound) and not a radar system.

- True
- False

Check



Experiment 4 - Procedure (1/1)

Experiment 4: Transmission and absorption of microwaves through a human organ

- In the next experiment, a hand is held between the transmitter and receiver.
- What can be observed?
- What conclusions can be drawn about the composition of the human body?

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Experiment 4 - Evaluation (1/2)

If you put your hand between the transmitter and receiver, the signal is almost completely attenuated.

- True
- False

Check

Which statement is correct?

- There is almost no water in the human body, which is why it absorbs microwaves particularly well.
- The human body consists of approx. 75% of water, which is why it transmits microwaves particularly well.
- The human body consists of approx. 75% of water, which is why it absorbs microwaves particularly well.

Experiment 4 - Evaluation (2/2)

How is food heated in a microwave oven?

Food is heated in a microwave oven by the interaction of microwave radiation with ______ in the food. The ______ stimulate the water molecules in the food to rotate and align rapidly, as these molecules have a ______. This rapid rotation creates ______ between the water molecules. This friction creates ______ which spreads through the food, heating it. It is the conversion of energy from microwave radiation to thermal energy through the movement of water molecules that heats the food.

- microwaves
- heat
- water molecules
- friction
- dipole nature

Check

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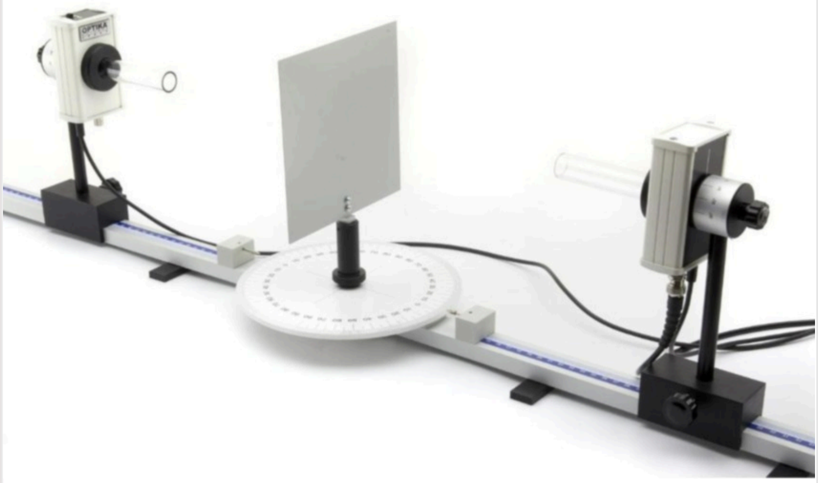
Experiment 5 - Procedure (1/1)

Experiment 5: Transmission and absorption of microwaves through a metal body

- Set up the experiment according to the illustration.
- A metal plate is placed in the middle of the arrangement.
- What can be observed at the receiver?



Experiment 5 - Evaluation (1/1)

How does the volume change when I insert a metal plate into the arrangement?

- No sound is heard, therefore the receiving unit is not receiving a signal.
- The volume remains unchanged. The microwaves penetrate the metal body completely.
- The sound becomes quieter, i.e. some of the microwaves penetrate the metal body and some are reflected or absorbed.

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Experiment 6 - Procedure (1/2)

Experiment 6: Microwave reflection

- Set up the experiment according to the illustration. Make sure that the metal plate is aligned along the zero point of the protractor. The rail on which the transmitter unit is mounted makes an angle of 45°.
- Set the volume on the speaker just below the hearing threshold.

Experiment 6 - Procedure (2/2)

- While holding the left arm in position, twist the right arm counterclockwise.
- Observe the change in volume.
- Is there a point at which the volume is at its maximum?

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Experiment 6 - Evaluation (1/1)

What can be observed when the angle changes?

- The received signal increases in intensity and reaches its maximum value at 45°.
- The received signal increases in intensity and reaches its maximum value at 30°.
- The received signal decreases in intensity and reaches its minimum value at 45°.

Why is the signal maximum at this angle? Because then...

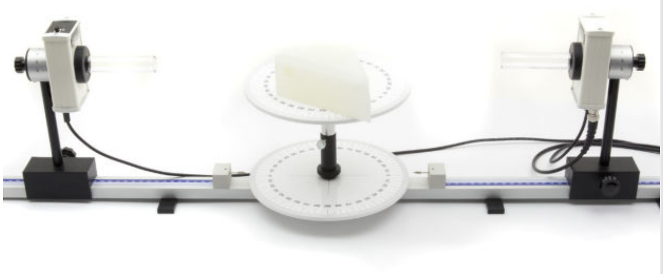
- [ ] Angle of incidence $=$ dropout angle
- [ ] There is no mathematical connection.
- [ ] Angle of incidence $-$ dropout angle $= 0$
- [ ] Angle of incidence $-$ dropout angle $= 1$

Check

Experiment 7 - Procedure (1/2)

Experiment 7: Microwave refraction

- In this experiment, we will now investigate whether a paraffin prism, like an optical prsima for visible light, is capable of producing refraction of microwaves. Set up the experiment according to the illustration.
- In this position the angle at the centre of gravity is $A = 45^\circ$. The value of the angle of incidence i can be read on the upper goniometer. Choose for example $i = 30^\circ$.



It is recommended that the transmitter $25cm - 30cm$ away from the prism to minimise the microwaves that do not pass through the prism at the receiver.

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Experiment 7 - Procedure (2/2)

- First align the receiver directly opposite the transmitter. What can be observed?
- Now hold the left branch and slowly turn the right branch counterclockwise. Note the position where the signal reaches its maximum value. In this way, the total angle of deflection can be δ, taking into account the position of the branch on which the receiver is standing, can be determined on the lower protractor.

Experiment 7 - Evaluation (1/1)

When the receiver is aligned with the transmitter, it receives no signal because the wave beam sent by the transmitter is deflected by the prism.

○ True

○ False

Check

From geometric considerations we obtain for the deflection angle:

$\delta = i + e - A,$

one uses this formula, with the known values for δ, i, A the angle can be e Are calculated.

One obtains for the angle e the following value:

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Experiment 8 - Theory (1/1)

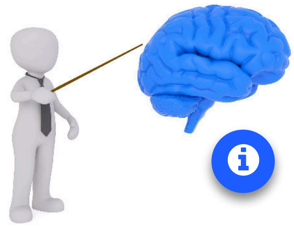
Experiment 8: Total reflection of microwaves

The refractive index n is a quantity that depends on both the material and the wavelength at a defined temperature. Paraffin is a mixture of different alkanes with refractive indices of 1 to 1.4 in the case of microwaves. In this experiment, the refractive index of paraffin is to be measured at a frequency of $10,5GHz$ be determined.

In order to determine the refractive index, we make use of the phenomenon of total reflection and examine the transfer of a wave from a medium to air.

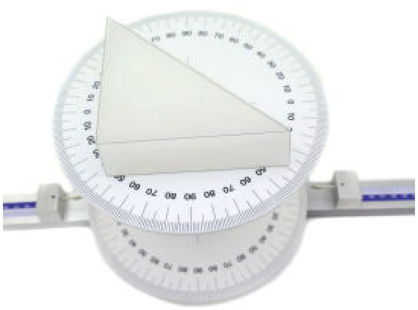
The refractive index is related to the critical angle α_G in the following context:

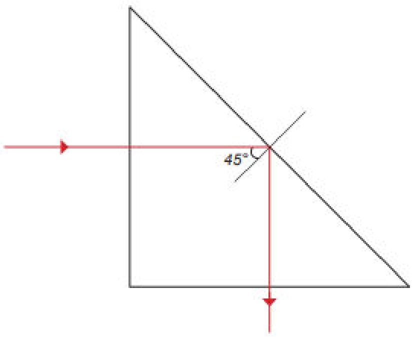
$\alpha_G = arcsin(\frac{n_2}{n_1})$, with $n_2 = 1$as it is the transition in air.



Experiment 8 - Procedure (1/2)

- Set up the experiment according to the illustration. The wave reaches the prism at a right angle and is therefore not deflected. It then maintains its direction and reaches the inclined surface of the prism at an angle of 45°.





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Experiment 8 - Procedure (2/2)

- Check at what angle the wave is fully reflected by holding the left branch and turning the right branch anti-clockwise.

Experiment 8 - Evaluation (1/1)

At what angle between the transmitter and receiver unit is the signal strongest?

- 0°
- 90°
- 45°

If the angle of incidence is greater than the critical angle, the beam is completely reflected (total reflection), otherwise it is refracted.

- True
- False

Check

The critical angle is therefore:

Thus, we obtain a value for the refractive index of:

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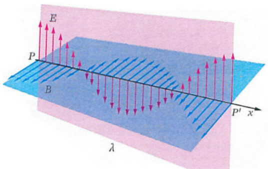
Experiment 9 - Theory (1/1)

Experiment 9: Polarisation of microwaves

As already mentioned in the theory section, an electromagnetic wave consists of an electric field $\vec{E}$ and a magnetic field $\vec{B}$ which are perpendicular to each other and to the direction of propagation. The direction of the electric field vector indicates the direction of polarisation.

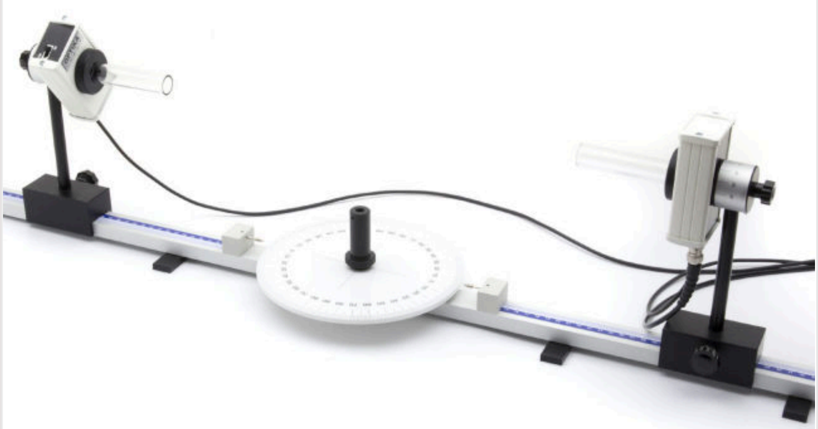


To determine whether the microwaves emitted by the transmitter are polarised, the orientation of the transmitter unit can be changed. There is a protractor on the back of the transmitter. By loosening a small locking screw, the transmitter can be rotated 90° in either direction.

Experiment 9 - Procedure (1/1)

- Set up the experiment according to the illustration.
- Set the volume of the received signal to a medium value.
- Now start turning the transmitter and watch when the signal goes out.

Additional task:



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Experiment 9 - Evaluation (1/3)

At what angle must the transmitting and receiving units be to each other for the signal to go out?

- 30°
- 45°
- 0°
- 90°

Why does the signal go out at this angle?

- The transmitter emits microwaves only at certain angles of rotation.
- The receiver has a polarisation filter built in and under this angle the microwaves do not pass the polarisation filter.
- The receiver can only detect microwaves when it is at the same angle to the transmitter, otherwise the microwaves are "twisted".

Experiment 9 - Evaluation (2/3)

How does a polarising filter work?

A polarising filter works by only letting through waves that vibrate in a certain ______ and blocking all others. This means that when waves hit the filter, only the waves that vibrate parallel to the ______ of the filter can pass through. The principle is based on the property of transverse waves to oscillate in certain planes of vibration. By selecting the correct ______ of the filter, one can control which portion is allowed to pass.

- direction
- orientation
- polarisation

Check

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Experiment 9 - Evaluation (3/3)

What does the experiment show regarding the type of polarisation?

- The electromagnetic wave generated by the transmitter is linearly polarised because the electric and magnetic field vectors always oscillate in the same direction.
- The electromagnetic wave generated by the transmitter is circularly polarised because the electric and magnetic field vectors move in a circular path.

What are polarising filters used for in everyday life?

Mark the correct terms.

Photography, LCD, binoculars, sunglasses, microscopy, 3Dcinema, astronomy, stressanalysis.

Check

Additional task:

Experiment 10 - Procedure (1/2)

Experiment 10: Determining the plane of polarisation of microwaves

- Set up the experiment according to the illustration and set the intensity of the acoustic signal to an average value.

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Experiment 10 - Procedure (2/2)

- Now first use the grid in horizontal alignment of the slots and observe how the signal of the receiver changes.
- Now turn the grid around 90° so that the slots are now aligned vertically.

Horizontal grid orientation

Vertical grid orientation

Experiment 10 - Evaluation (1/1)

Which statement is correct?

- If the grid is oriented vertically, the signal is retained, whereas it is cancelled if the grid is oriented horizontally.
- If the grid is oriented horizontally, the signal is retained, while it is cancelled if the grid is oriented vertically.
- The signal is maintained regardless of the orientation.

In which direction does the electric field vector oscillate? $\vec{E}$?

- In the vertical plane.
- In no defined level.
- In the horizontal plane.

Hint:

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Experiment 11 - Theory (1/1)

Experiment 11: Diffraction of microwaves at a slit

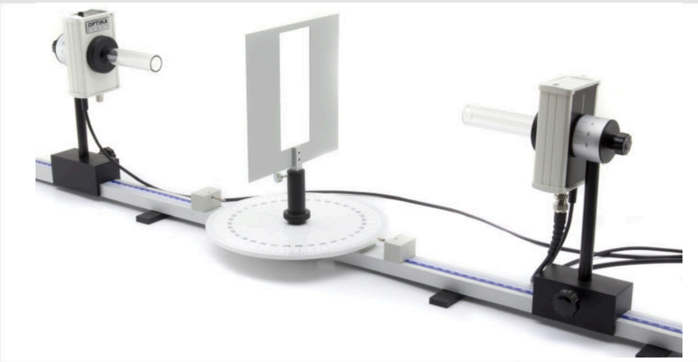
Diffraction of waves describes the phenomenon where waves are deflected around obstacles or through openings (such as gaps). Microwaves are electromagnetic waves, and when they encounter a gap that is approximately the size of their wavelength, they are diffracted.

When microwaves hit a narrow splat, the following happens:

1. They spread in undulating fronts emanating from the slit.
2. The pattern that emerges behind the slit shows a central main maximum (most intense point of the pattern), followed by several weaker secondary maxima and minima.
3. The width of the main maximum and the positions of the secondary maxima can be used to gain information about the wavelength of the microwaves.

Experiment 11 - Procedure (1/1)

- Set up the experiment according to the illustration. Make sure that the transmitter is not more than $30cm$ from the slit and examine the intensity distribution of the signal as a function of the angle between the transmitter and receiver. To do this, move the receiver slowly first counterclockwise and then clockwise.



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Experiment 11 - Evaluation (1/1)

What could be observed?

- The intensity distribution of the signal is independent of the angle.
- In the central position, the intensity is minimal.
- In the central position the intensity is maximum.

The following relationship between the central maximum and the first minimum applies:

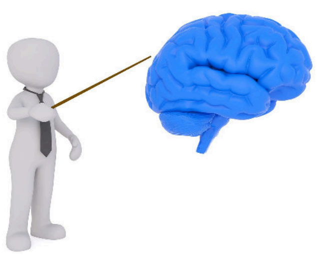
$sin(\alpha) = \pm\frac{\lambda}{d}$,

where α the displacement angle of the receiver, λ the wavelength and d is the gap width.

Determine the wavelength of the microwaves:

Hint:

Experiment 12 - Theory (1/1)



Experiment 12: Diffraction of microwaves at a double slit (Young's double slit experiment)

In this experiment, a double slit is used instead of the slit. When waves hit the double slit, the following happens:

1. Each slit acts as a source for wave fronts that propagate in wavelike patterns.
2. Where wave crests (maxima) from one slit meet wave crests from the other slit, they interfere constructively, resulting in an intense maximum.
3. Where wave crests from one slit meet wave troughs (minima) from the other slit, they interfere destructively and cancel each other out. The result is a minimum.

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Experiment 12 - Procedure (1/1)

- Set up the experiment according to the illustration. Use the double slit as the diffraction object.
- As before, investigate the angular dependence of the intensity.

Experiment 12 - Evaluation (1/1)

What could be observed?

- In the central position, the intensity is minimal.
- The intensity distribution of the signal is independent of the angle.
- In the central position the intensity is maximum.

The following relationship between the central maximum and the first minimum applies:

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

where α the displacement angle of the receiver, λ the wavelength and a is the distance between the two columns.

Determine the wavelength of the microwaves:

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Conclusion

Fill in the missing words.

Microwaves are a form of electromagnetic radiation that has a specific range of wavelengths within the electromagnetic spectrum. When microwaves encounter different materials, various phenomena can occur. One of these phenomena is ______, where microwaves are absorbed by a material. This is the reason why water in food is heated in a microwave oven. Another phenomenon is ______, where microwaves bounce off a surface, much like light reflects off a mirror. Finally, when microwaves encounter gaps or obstacles, the phenomenon of ______ can be observed, where the microwaves are deflected and form wave-like patterns.

Check

Slide	Score / Total
Slide 19: Electromagnetic radiation	0/3
Slide 20: Properties of microwaves	0/1
Slide 30: Influencing factors Signal interference with microwaves	0/3
Slide 34: Multiple tasks	0/2
Slide 35: Multiple tasks	0/2
Slide 37: Absorption of microwaves by plastic pools	0/1
Slide 38: Multiple tasks	0/2
Slide 40: Multiple tasks	0/2

Total score 0 / 48

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