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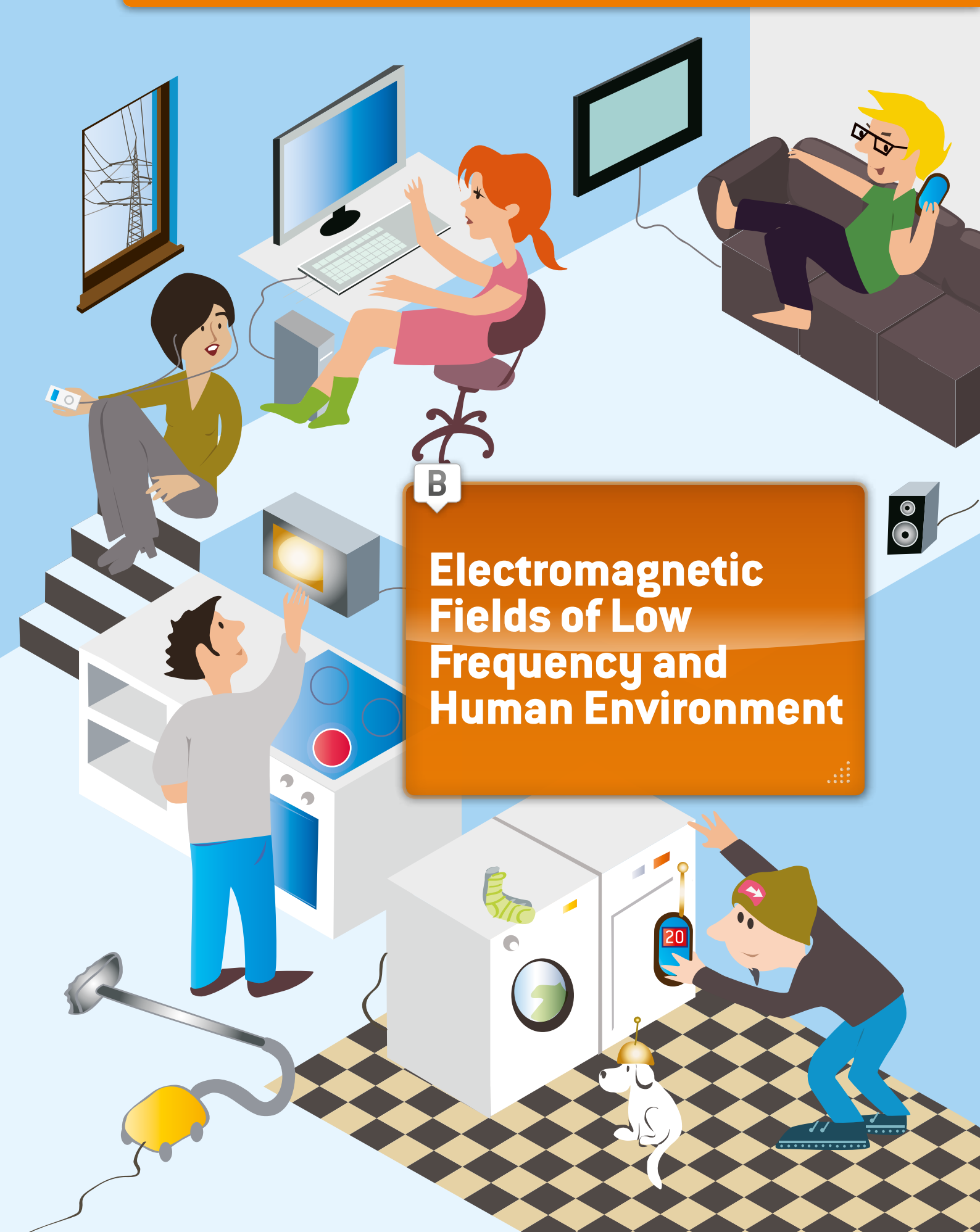


Electromagnetic Fields of Low Frequency and Human Environment

INTRODUCTION

In nature, electromagnetic fields are a common occurrence. Natural electric and magnetic fields encompass the earth, its atmosphere, and the space surrounding the earth. Humans themselves are a source of electromagnetic fields of different frequencies as well. Apart from natural sources, there also exist artificial sources, which, supposedly, are not harmless to humans. The aim of this unit is to make our students aware of the omnipresence of these fields in our surroundings.

N.B.: According to the latest research, low electromagnetic radiation is considered to be harmless to the human body, compared to the high electromagnetic radiation of an X-ray or MRI. Nevertheless the so-called electromagnetic smog emitted, e.g. by mobile phones, is still a much-discussed issue in the public arena.

Key concepts:

Physics (magnets and electromagnets; Generator; Faraday's law; Maxwell's law; electromagnetic fields; radiation spectrum); Mathematics (Equation graphs); Environment (Environmental pollution)

Ages:

The unit is recommended for students aged 12 to 19 years.

- Ages 12–14: survey, measurements of magnetic-field induction and qualitative analysis
- Ages 15–19: survey, measurements of magnetic-field induction, quantitative analysis, preparing graphs.

RESOURCES

Graphics and questionnaires can be created using spread sheets, e.g. those by Microsoft Excel or Open Office.

There are free online tools for creating questionnaires, e.g. Google Docs (for documents and spread sheets).

You can take measurements using smart phones or PDAs (with electromagnetic field measuring capabilities). There are several apps available for free.

CORE

The following diagnostic and therapeutic instruments used in the medical arena can be a source of electromagnetic fields: X-ray apparatus, computer tomograph, magnetic resonator, instruments for magnetotherapy and magnetostimulation, and instruments for diathermy.

Further artificial sources are: power lines, radio and TV stations, radio-navigational and radiolocation instruments, mobile phones, any household-electrical devices. The condensation of these sources is referred to as electromagnetic smog.

In order to evaluate the average user's level of knowledge on electromagnetic fields of low frequency in these devices, 1,000 students were interviewed in a survey. The results turned out to be alarming. Only 14 % of those asked had a notion of what electromagnetic smog was and of those, only 5 % were able to define this notion correctly. To the question "Please mention electromagnetic sources known to you", 36 % of those asked could not give any answer. The other participants pointed out the devices listed in the questionnaire.

On the basis of questionnaires, we can create a ranking of these devices' harmful potential. In order to verify the validity of the ranking, we can measure the magnetic fields produced by these devices. For this purpose we used a field measurer in a smart phone, a PDA. The results of the measurements showed that the students' ranking was not correct.

Input

The general aim is to analyse electromagnetic fields in the human environment, and to raise students' awareness about this topic.

The students fill in a questionnaire on a computer. To simplify the data collection you can use a free online tool. In doing so, you can create a form. Students can access and fill in this form on the Internet, following a link. All of the collected data can be entered in a spread sheet, which you can download in the desired format. You can instant-

ly transform the results of the survey into percentages and graphs in a spread sheet. You can also create graphs in a spread sheet.

Afterwards, students measure the change of magnetic fields of different household devices (linear and three-dimensional). To do so, they use the geometer in the smart phone or PDA.

They measure the magnetic induction in 10cm intervals ① and enter the results in a table. The spread sheet plots the main graph.

Magnetic-field distribution measured on the plane (isolines). ② ③

Analysis

The students use the collected data from the survey and the measurements to plot graphs. The graphs are then discussed and analysed.

For example, when prompted to "please give examples of any sources of electromagnetic fields known to you", possible answers are "I know ...", "I don't know ...". A round graph can show the results.

For the question "Have you ever heard about 'electromagnetic smog'?", more than one answer is possible, so you can switch to bar graph.

Answers to the question "What appliances will, in your opinion, badly affect your health", can be presented in the graph y(x) (x – the name of the equipment; y – number of people).

Students then can mathematically process the measurements (imprecise measuring instruments or imprecise human senses, e.g. sight, may cause some measurement inaccuracy). Results can be compiled in a spread sheet.

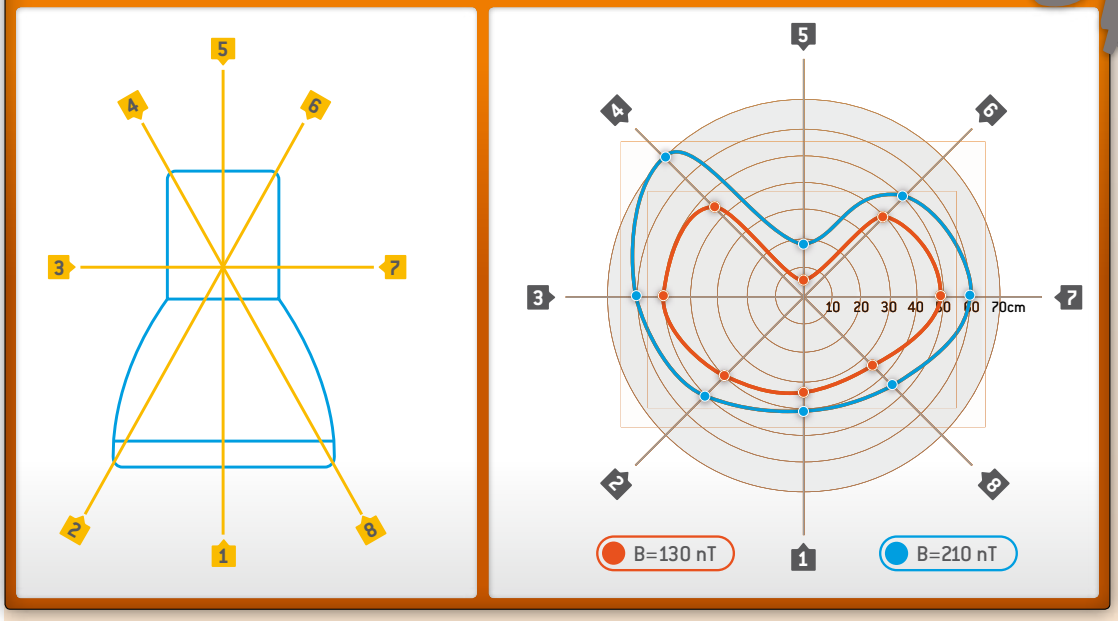
Example: "Magnitude of magnetic induction B [nT] of a certain piece of electric equipment (using students' own measurements) compared to the active distance marked with a colour". ④ ⑤

In concluding the analysis, they can compare the equipment's magnetic-field intensity and the exposure time (for example Graph y(x) :
x – the induction of magnetic field B[nT] and the exposure time t[h] – weekly dose ; y – the name of the equipment).

Output

The induction value of the devices' magnetic fields (usually given by manufacturers) as well as the exposure time are very important when it comes to analysing the influence of electromagnetic fields on humans.

② ③ **Magnetic-field distribution measured on the plane (isolines)**



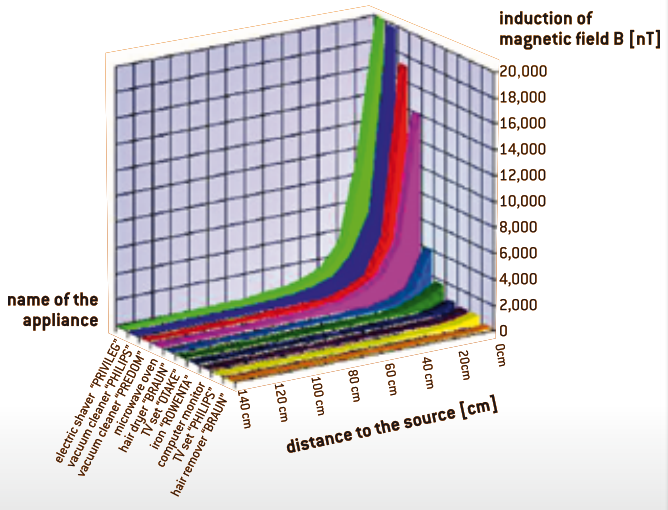
④ Comparison of the magnitude of magnetic induction of certain pieces of electric equipment

Distance to the source (cm) ❯	0	10	20	30	40	50	60	70	80	90	100	110	120
Vacuum cleaner „Philips“	19,755	5,695	2,560	1,200	754	461	331	247	187	162	136	109	103
Computer monitor	666	225	109	63	50	41	30						
Hair dryer „Braun“	3,940	1,043	464	206	133	85	69	51					
Shaver „Privileg“	19,980	9,450	3,320	1,432	844	500	341	232	180	127	102	78	67

The information on exposure of specific body parts is also very important. Students could discuss the results of the analysis, make posters for other students, and share their results with other classes, or surrounding schools. This could be done by using a common wiki or by disseminating the online questionnaire.

Additionally, a simulation of MRI exposure at phet.colorado.edu/en/simulation/mri can be helpful to understand how strong electromagnetic fields may affect the human body.

⑤ Diagram of the dependence between the magnetic field's B [nT] induction and the distance [cm] for selected electric appliances



CONCLUSION

Electromagnetic fields control many biological and physiological processes in the human body. For example, they influence the structure of the protein components of membrane channels and the distribution of ions. They affect liquid crystals contained in the body, especially those liquid crystal components of biological membranes.

The possible influence of low-frequency electromagnetic fields on the human environment is a crucial problem but, as the questionnaires have shown, generally not a well known one. Penetrating this problem of unawareness is a first step for presenting the subject to an average user of electric devices. The point is not to be afraid of electromagnetic fields, but not to disregard the problem either, and to make sure they are used in a proper fashion, e.g. avoid using many electrical devices at the same time; TV, computer, audio equipment; avoid spending lots of hours in front of a computer or TV screen; switch off Wi-Fi etc.).