DEBATE AND EDUCATION

The pedagogical aspects in the physical measurements provided in medicine

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Abstract

Nowadays, the graduates of medical faculties should be able to use up to date complicated technical devices as well as various diagnostic and therapeutic methods based on physical laws and processes. Therefore good knowledge in physics (including some fields of modern physics) is expected to be mastered by students during their studies of physics at the faculty. The shortness of time that is available for the teaching of physics has forced us to the laboratory exercises to the maximum extent. In this contribution, some special measurements will be described. The authors also discuss the possibilities of applying new practical and theoretical approaches, and stress the significance of the teaching of applied physics at medical faculties for the quality of medical care in the future. *(Ref. 18.)*
Key words: teaching of applied physics, medical study, medical care, technical devices, diagnostical methods, therapeutical methods

Although the existence of the Institute of Medical Physics at the School of Medicine of Comenius University (CU) began in the school year 1923/24, the first references dealing with the request to establish this department date from earlier periods (Kukurová, 1997; Kukurová et al, 1993, 1997; Ďuriš et al, 2000; Traubner et al, 2000).

The establishment and existence of this workplace at the School of Medicine was connected with the opening of the first year of medical studies and with the foundation of theoretical departments. It took place in the beginning of the year 1920 at the conference of professor-staff of the School of Medicine under the leadership of the Comenius University in Bratislava.

Out of all medical faculties in the Czecho-Slovak Republic and even in the middle Europe, it was the first pedagogical scientific workstation specialised in this area. During its short history, the tuition of medical physics and biophysics has led to the application of cybernetics, instrumental techniques, biostatistics, computational techniques, etc. The development of modern medical physics reflects especially the enormous advancement in technical and instrumental techniques. There is no doubt that the teaching of medical physics is now irreplaceable in all medical training programmes (Kukurová, 1997; Kukurová et al, 1993, 1997; Ďuriš et al, 2000; Traubner et al, 2000).

There are many areas, where medical physics can be useful much more than it is assumed (Kukurová et al, 2000; Hoyos, 2001; Study Program, 2001; Vilensky, 2001). Therefore in the past years, the Institute has started to apply a new teaching approach of biologic-experimental character (Kukurová et al, 1993; Ferencová, 2000).

General structure of applied physics tuition

The general structure of teaching is based on the definition of experiment with the accent on the obtaining and processing of information, which is the base of scientific work. However at the same time it represents one of the most difficult problems in connection with clinical practice (Kukurová, 1997).

Currently, the extent of teaching is one semester, three hours of lectures and three hours of practical training weekly, including specialised lectures provided in the last three years of the studies.

The range and content of the teaching of medical physics in the frame of general medicine (Kiňová, 1993; Ďuriš et al, 2000)

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and stomatology courses (Study program, 2001) are very similar, however with small variations between the medical faculties in the Czech and Slovak Republics.

Brief syllabus

Medical Physics and Biophysics in the system of medical education. Theory of measuring and basics of the Biometrics. Structure of matter, ionising and non-ionising radiation, interactions. Molecular biophysics. Biophysics of the cell, tissues and organs. Thermodynamics of living systems. Biorhythms. Biomaterials. Biomechanics of biological systems. Biophysics of analysers. Biosensors. Regulation systems in living organism. Biosignals (origin, recording, computing, saving, analysis). Ecological biophysics and protection against negative physical factors. Modelling. Biophysical base of diagnostics and therapy. Imaging methods. Physical principles of technical equipment in medicine.

The proposal is prepared for the discussion as to whether two independent undergraduate courses and one postgraduta course of medical physics are to be formally developed at our medical faculties in the Slovak Republic.

It seems that this new orientation will to subdued to a long step-by-step process of development requiring new materials to be edited and new equipment to be prepared according to the difficulty level. This aim has been met participating in the edition of seventeen titles devoted to medical physics and or biophysics. Hence, the tradition of the Institute in creating textbook literature has benn maintained. The textbooks are published in Slovak and English mutations. The first textbook in the former Czecho-Slovak Republic titled "Biophysical elixir, by Kukurova et al." was issued in 1992. This book was used at all medical faculties in Czech and Slovak Republics (Kukurová et al, 1993).

Requirements met by graduates of medical faculties

In the framework of our new approach we have clearly formulated requirements that are to be met by the graduates of medical faculties in conincidence with medical physics knowledge and biophysical thinking. They are related to the following items (Kukurová et al, 1993):

I. Measuring protocol

Objective: Physical measurement in medicine - description and results.

Topic: 1. Physical basis of measurement.
2. Selection of measuring procedure.
3. Specification of the most suitable hardware.
4. Statistical processing of data.
5. Calculation, graphical representation.
6. Summary with medical application.

II. Solution of the physical problem applied to the given medical situation.

III. Theoretical part consists of questions which should be answered briefly, optionally with a scheme.

— The biological system's function explanation

Question: Which of the physical principles can be used to explain the given phenomenon explanation (mathematical interpretation, theoretical basis of explanation, scheme).

— Physical interpretation

Question: Give possible applications to the physiological and pathological functions of the biological system (cell, tissue, organ, analyser, organism level).

— Selection of the factor of a physical influence

Ouestion: a) The possibilities of detection and specification of the interaction basis of its presence.
b) Its influence on the organism (specification of functions involved).
c) Which tissue properties (defined by its structure) are determined by it?

— Simple biophysical, mechanical and electrical model descriptions of the regulation, tissue properties or artificial organ substitution (Ferencová, 1998; Study program, 2001).

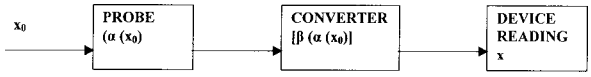
— Physical properties of basic medical diagnostic or therapeutic methods.

In an attempt to make the practical education of medical physics and biophysics more effective for the students, we have prepared a learning aid consisting of 45 worksheets in an algorithmic form. This aid enables the students to make a correct record of the performed experiment.

Under our conditions, each worksheet in our conditions contains the following data: the number of the exercise, date, the title of project.

Worksheet structure

1. Topic
2. Brief description of the project. The actual realization of the experiment
3. Used devices and implements: For a closer description of the apparatus (device) that processes the value of the measured (input) quantity x_0 — using the probe to the value $\alpha(x_0)$ — using the converter $\beta[\alpha(x_0)]$, to the value output quantity x (device readings) we use, the folloving standard flow-chart that can be of use in coincidence with any of measuring technical devices:



The result is the relationship

$x=f(x_0)$

that is called the characteristics of the device. Apart from this analytical form, it can be also expressed, as a table or a graph.

4. The object of measurement.
5. Measured values and calculations
   a) Time data
   b) Tables
   c) Statistical evalution of the result.
6. Graphical representation of the results.
7. Results.
8. Conclusion: The most important part of the worksheet (protocol). This part contains the evalution and a brief formulation of the conclusion. It is an analytical view of the obtained results. Based on the style of experimental work, the conclusion from the experimentally obtained results is more valuable than their acquirement. Therefore, the sense of practical training of medical biophysics is to evaluate critically all the obtained results, exercising student's own knowledge. In such a way a student can in such a way show his abilities to think about the problem and to associate the knowledge from all related branches. The latter skills reflect how the student has mastered the given subject.

Physical methods in medicine

For more advanced students Institute of Medical Physics and Biophysics offers courses in other methods via compulsory optional subjects:

A) Electromagnetism in medicine
B) Imaging methods in medicine

Electromagnetism in medicine

Brief syllabus

Intrinsic electric and magnetic biosignals — bioelectric function of cells, subthreshold membrane effects, active properties of membranes and tissues, impulse transfer. Biomagnetic measurements. Electric and magnetic activity of neutral tissue — EEG, EMG — their sources, lead systems, imaging, computing and analysis principles. Electric properties of biological tissues and their measurement, impedance pletysmography, impedance tomography, electrodermal responce. Electroretinogram, electrooculogram. Characteristics of electromagnetic field and their interaction with organism. Electric and magnetic stimulation of neural and myocardial tissue, defibrillation of heart. Application of direct and alternating current — physiotherapeutic systems. Laser as optical electromagnetic radiation — its interaction with organism, application. Electrodes, electric safety — micro- and macro-shock, protection against injury by electric current.

The aim of the subject

The aim of the subject is to manage basic principles of electromagnetism that are nesessary for understanding of electric and magnetic effects in an organism and interaction of the organism with external electric and magnetic field for diagnostic and therapeutic purposes.

Imaging methods in medicine

Brief sylabus

Thermometry and thermography — infrared radiation, liquid crystals, microwaves, image creation and their use. Optical imaging methods — microscopy, endoscopy — principles of image creation, types of equipment. X-rays imaging methods — sources, interactions with the medium, detection, image creation and imaging systems, computed tomography, therapeutic use, protection against radiation. Imaging methods using radionuclides — sources, interactions with the medium, detection, image creation and imaging systems, PET, SPECT, preparation of radionuclides, tracing, therapeutic use, protection against radiation. Ultrasound imaging methods — sources, interactions with medium, detection, image creation and image systems, Doppler systems, therapeutic use. Magnetic resonance imaging — principle, image creation and the use of imaging systems.

The aim of the subject

The aim of the subject is to manage physical principles and methods of image creation as a diagnostic tool and physical principles of effects of external factors on organism as a therapeutic tool.

Conclusion

Medical Physics is not an easy subject. One has to learn and to understand it at same time. Neither of the about is sufficient alone. This is a stringent requirement but when proper learning methods are applied it is a soluble problem (Kukurová et al, 2000; Ďuriš et al, 2000; Meško a Bernadič, 2001; Vladeck, 2001; Kluvanec, 2001).

Hence, the achievement of modern medical knowledge is a noble aim in coincidence with understanding of all kinds of diseases as well the ability to cure them. However, it cannot be accomplished without thorough knowledge and understanding of medical physics and its methods (Kluvanec, 1997, 2001).

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