Abridged Curriculum of the
Medical Physics Module
of the Physics M.Sc. course at the Budapest University of Technology

2013
BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

The Institute of Nuclear Techniques (BME NTI) of the Budapest University of Technology and Economics is a part of the Faculty of Natural Sciences. The institute consists of two structural units: the Department of Nuclear Techniques and the Department of Nuclear Energy. The mission of the institute is the education of physicists, environmental and power engineers in the field of nuclear measurement techniques and power generation.

PHYSICIST MSC, SPECIALISATION FOR MEDICAL PHYSICS

The scope of medical physics is the human application of the techniques and instrumentation of physics, especially for diagnostic imaging and radiotherapy. In agreement with the Bologna process, the former university education is replaced by the two-step BSc and MSc education. As a specialisation of the physics MSc, the Department of Nuclear Techniques of the Budapest University of Technology launches a novel education module to doctor the absence of medical physics education in Hungary. This MSc specialisation offers courses on medical imaging, nuclear medicine, X-ray diagnostics, MRI and radiotherapy. Medical courses such as anatomy and medical physiology are given by lecturers from the Semmelweis University.

THE GOAL OF MEDICAL PHYSICS EDUCATION

The medical physics specialisation aims at providing high level interdisciplinary theoretical and practical knowledge and readily applicable skills that can put into action in both the clinical and the R&D field. Strong contacts to medical institutions and to medical equipment vendors assure that the courses remain up-to-date and the skills readily applicable.

CURRICULUM OF THE MEDICAL PHYSICS SPECIALISATION MODULE

The duration of the medical physics MSc programme is 4 semesters, of which 3 is intended for theoretical education while the last is for preparing the Master's Thesis. The curriculum offers 120 European Credit Transfer System credit points.

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Further information can be found

- on the institute of Nuclear Techniques at http://www.reak.bme.hu/1/home.html
### The Medical Physics Curriculum: Overview Chart

<table>
<thead>
<tr>
<th>Subject</th>
<th>Semesters</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Lectures (6 credit)</strong>&lt;br&gt;lectur hours per week: theory/practical/lab/exam type/credit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Mathematical problem solving practical</td>
<td>0/2/0/f/2</td>
<td>2/2</td>
</tr>
<tr>
<td>2 Computer applications for technical and physics problems</td>
<td>0/0/2/f/2</td>
<td>2/2</td>
</tr>
<tr>
<td>3 Investments</td>
<td>2/0/0/f/2</td>
<td>2/2</td>
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<tr>
<td><strong>Core Lectures (23 credits)</strong>&lt;br&gt;lectur hours per week: theory/practical/lab/exam type/credit</td>
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<tr>
<td>4 Molecular and atomic physics</td>
<td>2/1/0/f/3</td>
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<tr>
<td>5 Material physics</td>
<td>2/0/0/f/3</td>
<td>2/3</td>
</tr>
<tr>
<td>6 Nuclear Physics</td>
<td>3/0/0/v/4</td>
<td>3/4</td>
</tr>
<tr>
<td>7 Particle physics</td>
<td>4/0/0/v/4</td>
<td>4/4</td>
</tr>
<tr>
<td>8 Computer simulation in statistical physics</td>
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<td>2/3</td>
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<tr>
<td>9 Physics laboratories</td>
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<td>6/6</td>
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<tr>
<td><strong>Module Specific Lectures (85 credits)</strong>&lt;br&gt;lectur hours per week: theory/practical/lab/exam type/credit</td>
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<td>10 Seminars I-IV.</td>
<td>0/2/0/f/2</td>
<td>8/6</td>
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<tr>
<td>11 Individual laboratories I-II.</td>
<td>0/0/7/f/7</td>
<td>19/19</td>
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<tr>
<td>12 Module Specific Lectures</td>
<td>7/0/0/v/10</td>
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<tr>
<td>13 Master’s Thesis</td>
<td>0/0/10/v/30</td>
<td>24/30</td>
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<tr>
<td><strong>Lectures of choice (6 credits)</strong>&lt;br&gt;lectur hours per week: theory/practical/lab/exam type/credit</td>
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<td></td>
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<tr>
<td>14 Lectures of choice I-III</td>
<td>2/0/0/f/2</td>
<td>6/6</td>
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<td><strong>Language Training</strong></td>
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<tr>
<td>15 Foreign language</td>
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<td>8/0</td>
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<tr>
<td>Total weekly hours</td>
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<tr>
<td>Total credits</td>
<td>30 30 30 30</td>
<td>120</td>
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<tr>
<td>Number of examination</td>
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<td>13</td>
</tr>
<tr>
<td>Number of final examination</td>
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<td>1</td>
</tr>
</tbody>
</table>
Module Specific Lectures

**Functional Anatomy (2/0/2/v/4)**
- Responsible lecturer: Miklós Réthelyi

**Physiology (3/1/0/v/4)**
- Responsible lecturer: György Nádasy

**Ethical Aspects of Medical Research (2/0/0/v/2)**
- Responsible lecturer: Péter Sótonyi

**Radiobiology (2/1/0/v/3)**
- Responsible lecturer: Péter Zagyvai
  - Lecturer: Géza Sáfrány, Csilla Pesznyák

**Health physics II (2/0/2/v/4)**
- Responsible lecturer: Péter Zagyvai

**Physical basis of Radiotherapy (2/0/2/v/4)**
- Responsible lecturer: Péter Zagyvai
  - Lecturer: Pál Zaránd, Tibor Major, Csilla Pesznyák

**Radiotherapy II. (2/0/0/v/2)**
- Responsible lecturer: Péter Zagyvai
  - Lecturer: Pál Zaránd, Tibor Major, Csilla Pesznyák

**Brachytherapy (2/0/0/v/2)**
- Responsible lecturer: Péter Zagyvai
  - Lecturer: Tibor Major, Csilla Pesznyák

**Quality Assurance and Legislation (2/0/1/v/3)**
- Responsible lecturer: Dávid Légrády
  - Lecturer: István Polgár, Csilla Pesznyák

**Medical Imaging (3/1/0/v/4)**
- Responsible lecturer: Dávid Légrády

**Physical basis of X-Ray Diagnostic (2/0/0/v/3)**
- Responsible lecturer: Imre Szalóki
  - Lecturer: Tamás Porubszky

**Nuclear medicine (2/0/1/v/3)**
- Responsible lecturer: Szabolcs Czifrus
  - Lecturer: Ildikó Balogh, Béla Kári, Péter Major

**Magnetic Resonance and Clinical applications (2/1/0/v/3)**
- Responsible lecturer: András Jánossy
  - Lecturer: Kálmán Nagy

**Ultrasound Imaging (2/1/0/v/3)**
- Lecturer: Rita Dóczi

**Introduction to Optics (2/2/0/v/5)**
- Responsible lecturer: Péter Richter

**Microscopy (2/0/0/6/2)**
- Responsible lecturer: Pál Máák

**Spectroscopy and structure of matter (2/0/0/v/3)**
- Responsible lecturer: Péter Richter

**Neutron and gamma transport calculation techniques (2/2/0/v/5)**
- Responsible lecturer: Szabolcs Czifrus

**Monte Carlo Methods (2/0/2/v/4)**
- Responsible lecturer: Sándor Fehér

**External Institutions and Companies participating in the lecturing:**
- National Institute of Oncology, "Frédéric Joliot-Curie" National Research Institute for Radiobiology and Radiohygiene, Semmelweis University (of Medicine), Mediso Ltd., PET Centre Ltd., General Electric Healthcare Hungary Ltd.
Curriculum of “Medical Physics Module” Specific Lectures

Radiobiology (2/1/0/v/3)
The course will focus on the understanding of radiation effects on the whole organisms, tissues and cells, as well as on the cellular causes leading to the death of normal and malignant cells. This helps to understand why a given dose of radiation induces tumors in one case while destroys tumor cells in another case. On the basis of radiobiological knowledge one can develop new therapeutic modalities to improve the survival of cancer patients. Radiation biology helps us to understand how and why ionizing radiation can be used to examine healthy and pathologial cell structures and to diagnose and treat various diseases.


Health physics II (2/0/2/v/4)
This course describes the determination of external and internal dose due to natural and – occasionally – artificial sources of generally low radioactivity based on nuclear physics and radiation protection knowledge gained while attending a BSC course in Physics. Topics discussed: detailed analysis of dose concepts, special problems (KERMA versus absorbed dose, equivalent and effective dose for assessing stochastic radiation effects), health physics control and regulation based on dose/risk dependence, principles and practice of dose and dose rate measurement, calculation of internal exposure, nuclear analysis for determining internal dose, compound radiation measurements: radon analysis, nuclear environmental monitoring.


Physical basis of Radiotherapy (2/0/2/v/4)
Scope of the subject: to foreshow the terminology of medical physics and measurement problems connected with the radiation therapy and matters connected to the radiation treatment planning. Syllabus of the subject: the methods of determination of anatomical data (CT, MRI, PET), major irradiation techniques (teletherapy, brachyterápia), radiation sources used in the radiation therapy (classical X-ray equipments, cobalt units, linear accelerators, radioactive sources, afterloading equipments). Description of the radiation field of the equipments used in teletherapy, major methods of measurement (ionization chambers, solid state detectors (film and thermoluminescent dosimetry)), measurements of the effect of beam modifying devices (hard wedge, dynamic wedge, block, MLC). Object of brachytherapy, kinds of radiation sources and their ways of application. Checking of therapy plans, the requirements of the radiation treatment planning according to the ICRU protocol. Quality assurance, quality control, safety requirements of teletherapy and brachytherapy devices, radiation protection and radiobiology in the radiation therapy.

Radiotherapy II. (2/0/0/v/2)
The lecture has been organized into three major parts: (I) Stereotaxic and extracranial radiosurgery, review of most important equipment, treatment planning systems and special dosimetry. (II) Advanced Image-Guided and Biological Guided Intensity Modulated Radiation Therapy (IMRT), physical optimization, imaging for IMRT, dose calculation, delivery techniques, dosimetry and QA/QC. (III) Total skin irradiation with electron beams, their special dosimetry and treatment delivery techniques. Literature: T. Bortfeld, R. Schmidt-Ullrich, W. De Neve, D. E. Wazer (Editors). Image-Guided IMRT, Springer 2006

Brachytherapy (2/0/0/v/2)

Quality Assurance and Legislation (2/0/1/v/3)

Medical Imaging (3/1/0/v/4)
Physical basis of X-Ray Diagnostic (2/0/0/v/3)


Nuclear Medicine (2/0/1/v/3)
Objective: to teach students the physical concepts related to nuclear medicine, the nuclear measurement technology issues and the basic ideas related to PET/SPECT technology and operation. Detailed curriculum of the subject: A brief summary of the methods of nuclear medicine, comprising the most important historical aspects. Summary of related nuclear phenomena and interaction types. Operating principle of the Anger camera, scintillating materials, photomultipliers, collimation techniques, implementations of the Anger camera, collimation techniques. Isotope diagnostics of plain image type: types of sources, efficiency, achievable image parameters, sources of noise, goals of examination. Principles of SPECT, methods of implementation, factors influencing the image quality and directions of application. Principles of PET, methods of implementation, factors influencing the image quality and directions of application. Production of isotopes needed for PET applications in accelerators, measurement and preparation of the isotopes for use. Possibilities to combine SPECT or PET with CT, advantages, achievable image parameters. Image reconstruction methods, their applicability, advantages and disadvantages. Modelling of PET/SPECT devices using the Monte Carlo method. Monitoring patient dose. Radiation protection in nuclear medicine, emergency procedures.


Magnetic Resonance and Clinical Applications (2/1/0/v/3)
Objective of the course is to give an introduction to concepts of magnetic resonance and its clinical use and to discuss measurement issues and practical applications. Detailed subjects: history, the place of magnetic resonance imaging (MRI) among medical imaging techniques, basic properties; basics of magnetic resonance (MR): relaxation, coordinate systems, Bloch equitations; impulse MR, spin echo; Fourier transformation (FT) and discrete FT; NMR spectroscopy; basic idea of MRI, one dimensional imaging; three dimensional imaging, frequency and phase coding; displaying the MRI image, resolution and field of view; basic imaging techniques and sequences; the contrast; imaging artifacts; special imaging techniques, advanced sequences; clinical applications of various sequences; the MRI hardware; safety and environmental issues.

Ultrasound Imaging (2/1/0/v/3)


Introduction to Optics (2/2/0/v/5)
This course is an introduction for MSc students, who have not taken Optics during their BSc studies. It is based upon the BSc level Electrodynamics. Main topics discussed include: models of light, transmission and reflection, geometrical/paraxial optics, interference, thin films, diffraction, optical grating, polarization, propagation in anisotropic media, waveguides, light and matter interaction, absorption, emission, operation of lasers, coherence, electro- and acousto-optics.


Spectroscopy and structure of matter (2/0/0/v/3)
This course organizes the knowledge obtained during the BSc training (electrodynamics of media, quantum mechanics, group theory, statistical physics, optics, optical measurement techniques) regarding the use of spectroscopy in materials characterization and structure elucidation. The methods covered are mainly optical techniques (infrared and visible/UV absorption and reflectance spectroscopy, Raman scattering, ellipsometry, optical rotation dispersion, circular dichroism) but other topics, as excitations of inner shells (X-ray and photoelectron spectroscopy, Mössbauer spectroscopy) will also be mentioned. The purpose of the course is to prepare the students to decide which spectroscopic methods to use for a given specific problem, and to be able to basically interpret the results.


Neutron and gamma transport calculation techniques (2/2/0/v/5)
The course helps students practically apply their knowledge gained during the „Reactor physics” course in Physics BSc. In the lectures and exercises of the course we first present simple radiation shielding problems the solution of which can be performed using approximate methods. Here students familiarize themselves with the MicroShield program. As proceeding to more advanced and complicated problems, students learn to use some of the features of the internationally acknowledged, Monte Carlo based, coupled neutron-photon-electron transport code MCNP. Students have to solve radiation shielding design problems, as well as reactor physics problems using the code.


Monte Carlo Methods (2/0/2/v/4)