MEDICAL PHYSICS AND ENGINEERING

EDUCATION AND TRAINING

PART I

Editors:
Slavik Tabakov, Perry Sprawls, Anchali Krisanachinda, Cornelius Lewis

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(Part I)

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The book MEDICAL PHYSICS AND ENGINEERING EDUCATION AND TRAINING (PART I) includes papers from many colleagues and aims to support the exchange of expertise and to provide additional guidance for establishing and updating of educational/training courses in Medical Physics and Engineering. To support this aim the book will be distributed as a free e-book through www.emerald2.eu (through link in MEP various links and resources).

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CONTENT :

FOREWORD

Medical technology for both diagnostic and therapeutic procedures is one of the corner stones of contemporary medicine. As a result the demand for suitably educated and trained specialists in medical physics and medical engineering increases worldwide. This requires special attention for the education and training of such specialists. At the same time the spectrum of medical equipment is expanding with many innovations, especially with the rapid advances and applications of digital technology. This makes the development and updating of University educational programmes and Practical training courses a difficult task. International collaboration and innovation in this field is imperative for the appropriate professional response to these challenges.

Some of the major national medical physics/engineering professional organisations (AAPM, IPEM, etc.) have specific guidance documents for the development of suitable education and training courses. These have been used as guide in various countries. At international level there is a need and opportunity for active roles by organizations such as the International Organisation for Medical Physics (IOMP), the International Federation for Medical & Biological Engineering (IFMBE) and their Union the IUPESM (International Union for Physical and Engineering Sciences in Medicine), as well as their Regional Organisations, the International Atomic Energy Agency (IAEA), the World Health Organisation (WHO) and other International Organisations.

Many Universities are joining forces through international projects to develop specific educational programmes, often based on the guidance and recommendations produced by the above organizations. Similarly Hospitals and Educational Institutions join forces to develop practical training courses. These activities require careful synchronisation, achieved through a number of International Conferences and Workshops organised in the last 15 years. Three of these were hosted by the Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, 1998, 2003, 2008), which also hosts the bi-annual International

College on Medical Physics. All of these activities were a powerful stimulus for new projects and joint professional education/training activities.

A number of these activities produced guides for international development of education and training. Some of these have special importance:
- "Medical Radiation Physics - A European Perspective", (1995), ISBN 1 870722 02 7, available free in PDF format at www.emerald2.net and www.emerald2.eu
- "Towards a European Framework for Education and Training in Medical Physics and Biomedical Engineering", (2001), ISBN 1 58603 151 1, IOS Press, Amsterdam
- The materials of the project BIOMEDEA and its associated Conferences (2004-2005), available from www.biomedea.org.
- The special issue "e-Learning in Medical Engineering and Physics", Journal of Medical Engineering and Physics, 2005, vol.27, N.7
- El Fisico Medico: Criterios y Recomendaciones para su Formación Academica, Entrenamiento Clinico y Certificacion en America Latina, OIEA, VIENA, 2010, STI/PUB/1424, ISBN 978-92-0-311209-3

Additional strong emphasis on professional education was given at the International College on Medical Physics at ICTP, Trieste, Italy and at the special International Workshops included at our largest professional events - the World Congresses WC 2003 (Sydney), WC2006 (Seoul), WC2009 (Munich). These were specially supported by IOMP, IFMBE and IUPESM.

The high interest in education and training led to a significant increase of the number of educational programs and training courses around the world. This was especially notable in Eastern Europe, where more than 15 MSc-level programs in Medical Physics/Engineering were established in the period 1994-2003. This is due to several factors, including the active educational programme of EFOMP (European Federation of Organisations for Medical Physics), the increased professional awareness (especially the EU policies associated with EurAtom), the book "Medical Radiation Physics - A European

Perspective", several EU projects, and others. These activities were continued in the Asian region with the support of the Asian Federations AFOMP and SEAFOMP and the collection of educational programmes for the large Workshop “Medical Physics and Engineering Education and Training – a global perspective”, held at WC2006, Seoul, 29 August 2006 (and co-organised by the Editors of this book).

In this book we have included many papers of colleagues presented at the above-mentioned Workshops (at World Congresses and at ICTP). These were mainly related to Medical Physics (reflected in most of the statistical data at the end of each paper) and later additional papers were accepted expanding the focus to Medical Engineering as well. We included also updated information from countries already covered in our previous book (1995) and this will give indication about the progress made in the past 15 years. We also tried to include papers describing various educational projects, especially e-Learning, thus presenting new teaching resources. The various papers in the book are organised roughly by geographical region, followed by information for some learning resources and projects.

After the publishing of the present book (part I) collection of materials from other countries will continue for the part II of the book, planned for 2012 – 2013.

We hope that the materials in the present book will help the exchange of expertise and will provide additional guidance for establishing and updating of educational/training courses in Medical Physics and Engineering. To support this, the book will also be distributed as a free e-book through www.emerald2.eu.

Finally we are grateful to all colleagues who submitted their papers for this book, to ICTP who printed it, and to all who supported the development of this project.

The Editors

IOMP Model Curriculum for Postgraduate (MSc-level) Education Programme on Medical Physics

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I. INTRODUCTION

The expansion of Medical Physics as a profession requires dedicated academic programs for the education and training of the young colleagues. At this time many countries do not have guidance on how to develop their education programmes. The experience in other countries provides the foundation for a project to produce a very useful Guide for development of new programs.

The Model Curriculum (Model Teaching programme) project was a spin off activity of the World Conference on Physics and Sustainable Development (November 2005, Durban, South Africa). It was supported both by the IUPAP (International Union of Pure and Applied Physics) and the IOMP (International Organization for Medical Physics). The project was discussed at the IOMP Education and Training Committee (ETC, 2006) and resulted in the formation of Work Group of experts (the authors of the article), which had a meeting during the EMITEL Conference in ICTP, Trieste, October 2008 and a number of Internet discussions. Being all active educators, the authors gathered expertise from countries with advanced Medical Physics education, as well as from countries which successfully developed their current education on this subject. This paper presents an overview of the main issues addressed by the Model Curriculum project. These include:

- Overall number of classroom contact and self-reading hours;
- MSc project and thesis;
- Structure of the Curriculum and Models of content delivery;
- Entry requirements and students' assessment;

- Principles of validation of courses/programs;
- Indicative content of the Curriculum.

II. OVERALL NUMBER OF CONTACT / SELF-READING HOURS

Medical Physics education is usually (and desirably) provided at the Master level (after completing a BSc-level degree). In general, the total number of learning hours associated with a postgraduate (MSc-level) educational programme (also called MSc course) include:

- Contact hours (lectures, seminars, tutorial, labs and practical exercises);
- Self-study hours (reading specified books and web-based resources and preparation for course works / exams);
- MSc project related hours (including the research and the writing of the MSc thesis)

The total number of contact hours (lectures, seminars and labs) in a postgraduate (MSc-level) education programme can vary according to the local University requirements and the level of self-reading requested by students. There are two educational models representing the approximate lower and upper limits of contact hours.

In case of high self-reading expectation, the overall contact hours could be of the order of 300 – 400 hours. However in this case each lecture hour has to be complemented by at least 2 hours additional self study (depending on the difficulty of the subject). To satisfy the simultaneous study of at least half of the student group (at a time) this model requires the existence of a good reference list and the availability of a library with the necessary resources, either in print or online. This model also requires good student testing during the delivery of education.

At the other extreme (when minimal self-study is expected) the overall contact hours could be of the order of 800-900 hours. This model is useful for Regions or Universities, where the libraries are not rich in resources, and most of the information is expected to be delivered during the lectures and labs. In this model the main resource which students have for preparation for exams is their lecture notes.

When distributing the contact hours, one needs to build a good proportion for labs and other practical hours. Their proportion could be estimated as 25% of all contact hours (preferably most of these in a clinical environment).

It should be emphasised, that contrary to some other University courses, attendance to Medical Physics lectures should be regarded as essential, and coursework delivery as obligatory. These requirements are very important for our dynamic profession, where books and other sources become out of date quickly.

As a rough estimate, the sum of class contact and self-reading hours of an MSc programme in Medical Physics would be around 1100-1300 (including time for the examination and feedback tutorials).

III. MSC PROJECT AND THESIS

The MSc project (or Diploma work) and related thesis is of great importance for the assessment of students' ability to apply the acquired knowledge into practice. This research element of the education element should follow the above-described taught element. The nature of Medical Physics education allows for minimal overlap between these two elements and the MSc projects should follow after the completion of the educational modules. It would be advisable the subject of the MSc project to be linked to a real practical problem in Medical Physics.

The volume of the MSc thesis is often given as around 15000 words, but this should not be a strict requirement, as different theses would produce results which would include elements which can not be measured this way (for example programming, drawings, etc.). However the thesis is expected to be "publication-like" – i.e. including all major elements of a typical research paper: Introduction; Literature Review; Materials and Methods; Results; Discussion; Conclusion; Reference list.

The difficulty of the project should be related to the approximate time, which the student is expected to devote to it. In many Universities this time is around 500-700 hours.

This MSc project time, added to the time for contact and self-reading above, would give an indicative overall length of the postgraduate (MSc-level) education programme of approximately 1700-1900 hours (in some educational systems this will be the minimum length). Again, variations related to local requirements could significantly change this figure. Normally this length would be delivered either within one-two academic year (full time studies) or in two-three academic years (part time studies). Some local regulations could require longer study time - e.g. 2 years for full time MSc programme. Similarly the taught element of the full-time programme could be extended over 1 whole year, and the MSc project could be developed over the second year (during which the student can have also some exposure to the real practice of the profession). Respectively such delivery of the programme could extend the Part-time delivery and completion up to 4 years.

IV. STRUCTURE OF THE CURRICULUM AND MODEL OF TEACHING DELIVERY

The MSc programme could be delivered either as a condensed full-time academic activity (most often over one year), or as a distributed part-time academic activity (most often over two years). Its organisation should be based on a progressive structure, as many of the topics require background from other previous topics. From this point of view a very suitable model for Medical Physics Education is the modular model. One module is a finite element of the studies, with separate assessment (for example Radiation Protection Module). Its length varies, but is often 30-40 contact hours.

In this model each subject from the educational structure is delivered in a condensed period of time (over 1-2 weeks). The model is very effective in countries, where the concentration of lecturers is not sufficient. The model allows for various lecturers to be called from other Universities (or cities and countries). The disadvantage of this model is related to the fact that when students miss certain element (due to illness, or other reason) they would have great difficulty to be in pace with the group.

A variation of the modular model is distributed delivery of lectures on different subjects, while keeping the logical link between them. This model is more convenient for the students, but puts great pressure on the organisation, as a missing lecture (due to lecturer's illness or other reason) could disrupt the logical line of knowledge delivery.

Perhaps a suitable balance between these two possibilities provides a good solution, which is used in a number of Universities. This balance could be based on mainly distributed delivery of the basic topics (for which one University could find local lecturers) and fully modular delivery of the special topics (what would require invited external faculty of lecturers).

Obviously this method of delivery must be based on grouping the subjects (modules) in two main categories – general topics (which all students will study) and topical modules (from which the student will select a limited number, depending on their interest). Later an example model for a curriculum with its modules is described

Other organizations of the delivery (by subject) are also possible - for example – Imaging group of modules, which would form a package including the physics principles, the medical application, the relevant equipment and its method of operations, various measurements and safety issues, etc. This however is very difficult to be applied in a small country, where the lecturers are often scattered in various cities and institutions. The advantage of this organisation is related to the better learning and examination of students. This method of delivery is suitable for a large University, which can afford to organise solely a MSc programme in Medical Physics (and even such University would need a number of honorary lecturers).

In most other cases the University issuing the degree must have agreements with other Universities (where some lecturers work and/or suitable laboratories exist). These inter-university agreements are vital for the organisation of MSc courses in small countries. A model suitable for smaller countries (and Universities) is collecting a faculty of lecturers (from other cities or countries) and maintaining a local Education Centre (which in principle could be not just for one country, but for a whole region). This model can have variations.

One variation could be all students to be registered at their own University (which can be different from the University hosting the Education Centre) and attend all optional lectures at this Centre (which in this case is the meeting point of students and lecturers). In this case the Centre should have honorary contracts with the host University. It is assumed that the students could attend the basic lectures at their own University. When the students complete the taught element of the programme they could develop their MSc project in their own University, and graduate from it. This model is cost-effective, but will depend heavily on the inter-university agreements (between the hosting University and the other Universities sending students to it).

Alternatively, the students can register with the University, where the Centre is established, complete all taught element there (basic and optional modules), then develop their MSc project in the Education Centre and graduate from the host University. This education delivery requires good investment in the foundation of the Centre (for equipment, laboratories, teaching room, etc). Its advantage is that in this case all teaching and research are in the host University (assuming the countries sending students have educational agreement with the host country). A plus of this model is that with time the host University will have a number of its own graduates to take part in the education process, what in future would decrease the cost for invited faculty.

V. ON-LINE STUDIES

The number of students following on-line courses and other e-Learning initiatives increased over the past 10 years. Most authors support blended delivery of e-Learning and classical learning [7, 8]. Contemporary web technology (e.g. Skype) allows for direct lecturing from distance, supported with specific on-line materials. Other technologies (e.g. Adobe Connect) allow sharing presentations/lectures.

Own development of bespoke e-Learning materials is very expensive, however a number of suitable and well used such materials exists on Internet [e.g. 14, 15, 16]. Their use however has to be specified in the Programme description/handbook. In such case the home University (offering e-Learning degree) has to agree on the use of these materials (blended with their own education) and has to consider inclusion of on-line teachers in the Programme Faculty of the MSc course (if appropriate). e-Learning is most suitable for remote areas, but its delivery without contact with real practising lecturers is not recommended. The best results of e-Learning are usually for further education of junior specialists, who already work in Medical Physics Departments as technicians, or similar. This way they have the necessary professional contact, as well as MSc project supervisors.

VI. ENTRY REQUIREMENTS

A normal entry requirement would be undergraduate degree (BSc-level) in Physics, Engineering or other relevant subject (based on minimum 3 years University education). The variation of undergraduate programmes and courses is enormous and the entry level should be decided for every single case. When this level is doubtful, an extra preparatory period (approximately one term) could be added. During this period the student will have to pass additional elements on Physics, Research methods, etc. If such model is used, we could expect that the Full Time delivery would extend over minimum of 2 years (e.g. 1/2 year preparatory + one year taught element + ½ year research project). Such education course could build very sound educational base and could include elements of further practical training (what otherwise would be difficult to organise as a separate activity).

Due to the variety of University undergraduate programmes, it is not possible to advice on specific entry requirements. Selecting students with an interview is always advisable, as this way the selecting panel could agree on the acceptable entry level, type of questions, etc.

VII. STUDENTS' ASSESSMENT

As usual standard written exams (2 to 3 hours exam writing time) are required for passing the educational modules. The percentage which the exam mark takes from the overall module mark is advisable to vary between 60 and 80%. This way the remaining 40-20% are for course work to assess the progressive build-up of Medical Physics knowledge (coursework in a form of essay on a subject, small design project, a set of tasks, etc given and assessed during the semester). The dynamics of our profession and the structure of knowledge does not allow for missing coursework (or any other type of home work). This work should be structured to be answerable in approx. 8 hours (by an average student). The course work has to be assessed and feedback given to the students before the exam.

Due to the relative difficulty of the Medical Physics exams, it is advisable for these to be distributed in two exam sessions (after each substantial term). At least 3 days revision time should be given in-between exams. In case of modular delivery the exam could follow directly the end of the module. It is a good practice for the exam questions to be confidentially agreed not only by the respective lecturers, but also by an External Examiner, who is from another University (or at least is not involved in the course delivery).

The pass mark of each module is to be decided by the University, but it should not be below 40% (assuming 100% is the maximum mark) for each element of the assessment - written exam and course work. Many Universities require for the minimal sum pass mark to be 50% and the written exam to be assessed by two examiners.

Assessment of the MSc thesis (or Diploma work) includes normally an oral exam (viva voce), where the student has to defend his/her project/hypothesis and answers the questions of the examiners. The number of examiners in the panel can vary according to local requirement. Normally the pass mark for MSc thesis is 50%. This mark should include approx 70-80% from the theses assessment and 30-20% from the actual oral exam presentation. A good practice can be introducing an Interim MSc exam (approx. 1 month after the beginning of the MSc research work), where the student presents his/her idea, initial literature search, expected results and working plan. This Interim exam can be assessed with 10% from the total MSc thesis mark, but could give an early feedback to the student for the development of his/her re-search and could prepare him for the final oral examination.

VIII. SUGGESTION FOR THE PROGRAMME MODULES

The syllabi of modules of the Model Curriculum include the main components necessary for initiating practice in the profession. However due to the dynamic development and expansion of the profession these have to be regularly updated. The Model Curriculum is based on a number of publications, collected over the last 15 years at special Conferences, Workshops, Seminars, Projects and Working Groups [1-11]. The increased interest in this field brought recently new materials on education and training [12, 13].

Based on these an indicative suggestion for the main modules in a MSc-level programme in Medical Physics (plus their % of contact hours) can be presented as:

Basic modules:
Basis of Human Physiology and Anatomy ~10%
Basis of Radiation Physics ~10%
Research Methods ~10%
Radiation Protection and Hospital Safety ~10%

Topical modules:
Medical Imaging Physics and Equipment 1 ~10%
(non-ionizing radiation - MRI, Ultrasound)
Medical Imaging Physics and Equipment 2 ~10%
(ionizing radiation – X-ray, Nuclear Medicine)
Radiotherapy Physics and Equipment ~15%
Other optional modules could also be included.

MSc project work ~ 25%

IX. INDICATIVE OUTLINE OF THE MODULES SYLLABI

Basic modules

<u>Basis of Human Physiology and Anatomy ~10%</u>

This module aim is to give to students background for their further studies and to help them in their future work with medical colleagues. From this point of view it is advisable for this module to be placed at the beginning of the teaching programme. It could have internal structure based on sub-modules (approx. 2 to 4 hours each), according to the main systems in the body (with emphasis on physiology). In principle it can be delivered as 5 to 8 days full time module. The lecturer(s) could use one of the many existing textbooks on the subject (suitable adapted medical physicists). For example a suitable book could be "Introduction to the Human Body", Tortora & Grabowski [11].

Basis of Radiation Physics ~10%

This module aims are to provide suitable background of the basic physics of the ionising and non-ionising radiations used for medical diagnostic or therapeutic purposes. The module will need some initial reminder of the radiation concept; fields and photons; the origin of different types of ionising radiation; the interactions of radiation with living organisms. The module may follow elements of existing Physics education, but has to include laboratories on Radiation measurement and has to include more detail about:

- Photon interactions: Elastic scattering, Rayleigh scattering, Compton scattering, photo-electric absorption, pair production. Interaction cross sections, and dependence on energy and atomic number. Absorption and attenuation coefficients.

- Particle interactions : Interaction of charged particles with matter; Electron-electron collisions, delta rays, polarisation effect, radiative losses; Heavy charged particles, Bragg peak. Stopping power and dependence on energy, atomic number, density.
Elastic scattering. Range.

- Radiation measurements: Concepts of fluence, absorbed dose, exposure, kerma. Methods of radiation detection: gas detectors, scintillation detectors, semiconductor detectors, thermoluminescence detectors, photographic film.

- Ultrasound: Acoustic propagation and interaction. Pulses and diffraction. The pulse-echo principle. Doppler effect. Acoustic properties of human tissues. Transducers.

- Electromagnetic radiation: Sources of radiation, interaction, hazards and medical applications for each: Lasers, Radiofrequency, Microwave, Infra-Red, Visible and Ultra-Violet.

<u>Research Methods ~10%</u>
The aim of this module is to introduce the basic principles of research methodology, related project planning and ethical issues; the practical applications of modern data processing in medicine (medical signals and image processing), including statistical techniques relevant to medical data. The module may include also study/application of relevant software (e.g. MatLab, SPSS, etc). The module may follow elements of existing Signal/Image Processing education and has to include more detail about:

- One dimensional signal processing : Sampling: Nyquist, aliasing, quantization; Spectral analysis: DFT, FFT, Hilbert, Hartley, Hough; Correlation and Convolution; Various Filtering methods.

- Two dimensional signal processing: Image perception and quality, Spatial frequencies; Image Enhancement and Restoration: Point operations, Pixel group processing, Global operations, etc; Image analysis: Segmentation, Morphological processing, Feature extraction, etc; Image compression; Foundation of backprojection reconstruction; Image transfer and archiving systems.

- Statistical methods: Frequency distribution and summary measures; Sampling distribution; Hypothesis testing; Analysis of variance; Basis of Time series; Regression.

<u>Radiation Protection and Hospital Safety ~10%</u>
This module aims to provide the theoretical background of the radiological protection requirements (ionising and non-ionising radiation), as well as fundamentals of general hospital safety. The

module may follow existing national methods for Risk assessment and has to include more detail about:

- Biological effects of ionising radiation; Dose response – relationships and factors affecting dose response; Quantities used in protection: Quality Factor, Equivalent Dose, Effective Dose; Background radiation; Organisations concerned with radiation protection (e.g. ICRP, IAEA, etc); Framework for radiation protection; Development of recommendations; National legislation concerning medical use of radiation; Personnel monitoring; Dose control for patients; Strategies for patient dose reduction; Shielding calculation, etc.

- Ultra-Violet radiation: Biological effects, Measurement, Maximum Permissible Exposure; Monitoring and protection

- Microwaves and Radiofrequency (including MRI): Classification, Biological effects, Measurement, Maximum Permissible Exposure; Monitoring and protection.

- Lasers: Types of lasers and classification of hazard, Biological effects; Measurement, Maximum Permissible Exposure, Monitoring and protection.

- Ultrasound: Classification, Biological effects, Monitoring and protection.

Topical modules:

<u>Medical Imaging Physics and Equipment 1 ~10%</u>
<u>(non-ionizing radiation - MRI, Ultrasound)</u>
This module aims to educate students in the physics of medical imaging with non-ionizing radiation (MRI and Ultrasound). Due to the rapid development of these imaging modalities (especially MRI) the module is expected to adapt regularly to the progress in these fields. The main parts of this module have to include more detail about:

- Magnetic Resonance Imaging

Physics of MRI; MRI Instrumentation; K-space; Different MR imaging methods; Pulse sequences; MR Contrast and Image quality; Health and Safety; MR Spectroscopy; Flow imaging; Perfusion, Diffusion and Functional MRI; Three dimensional reconstruction; Clinical applications of MRI; Image artefacts; Inter-relationship between medical imaging techniques.

- Ultrasound Imaging
US wave motion and propagation; Acoustic properties of biological media; Acoustic radiation fields; Safety measures; Transducers; A-mode; B-scanning; Doppler Ultrasound; Image artefacts; Blood flow measurements; Measurement of acoustic power; Clinical applications of US imaging; Image artefacts; Inter-relationship between medical imaging techniques.

<u>Medical Imaging Physics and Equipment 2 ~10%</u>
<u>(ionizing radiation – X-ray, Nuclear Medicine)</u>
This module aims to educate students in the physics of medical imaging with ionising radiation (X-ray and Nuclear Medicine Imaging). Due to the rapid development of these imaging modalities the module is expected to adapt regularly to the progress in these fields. The main parts of this module have to include more detail about:

- Diagnostic Radiology
X-rays production and equipment; Interaction of X-rays with matter; Radiological image quality; X-ray detectors: Film, Image Intensifier, Storage phosphor, Flat panel; Scatter radiation and filtering; X-Ray Computed Tomography; Scanner configurations; Reconstruction types; CT image display, windowing, CT numbers; X-ray patient dosimetry and protection; Optimization techniques; Clinical applications; Image artefacts; Inter-relationship between medical imaging techniques.

- Nuclear Medicine Imaging
Radionuclides and production of Radiopharmaceuticals; Disease-specific radiopharmaceuticals; Radiation protection in Nuclear Medicine; Image quality and noise; Nuclear Medicine instrumentation and quality control: Gamma camera, SPECT, PET, SPECT/PET-CT,

etc; Optimization techniques; General imaging principles, cardiac imaging, multigated studies, first pass studies, renal studies, modelling; Image artefacts; Inter-relationship between medical imaging techniques.

Radiotherapy Physics and Equipment ~15%
This module aims to provides the necessary background for the support of Radiotherapy Physics activities. Due to the rapid development of this field the module is expected to adapt regularly to the Radiotherapy progress. The main parts of this module have to include more detail about:

Interaction of radiation with tissues; Radiobiology in Radiotherapy; Radiotherapy dosimetry; External beam radiation and treatment planning; Megavoltage Linear Accelerator;; Radiotherapy with particle beams; Brachytherpay: High dose rate (HDR) treatments; Low dose rate (LDR) permanent implants; Beam models and planning tools; Treatment room design, machine commissioning and networking; Imaging in Radiotherapy; Quality management in Radiotherapy; Principles of Clinical application.

X. VALIDATION OF THE PROGRAMME
Usually a country with limited development in Medical Physics will have no experience in setting and accrediting a suitable post-graduate programme (course) in Medical Physics. Validating the programme by an experienced body will assure the local University (or Ministry of Education) that this programme is in line with the international standards. Additionally, the fact that the MSc graduates will work in Hospital environment (indirectly involved with patient health), makes the external validation an important element of the educational process.

IOMP has significant expertise allowing the provision of validation of such post-graduate programmes in Medical Physics and has set up of a special Validation and Accreditation Panel (VAP) of experts to the ETC Committee. This Panel (or sub-committee) could not only assess and validate the programmes, but could also provide External Examiners and suggest suitable lecturers. The activities, terms and internal rules of the VAP are still in discussion. It is expected

Validation activities of the IOMP to be implemented during the period 2011-2012. These will include: Validation requirements; Application Form, Validation Procedure and Validation Certificate (all to be found at the IOMP web site at implementation stage).

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Dr Slavik Tabakov, UK, Chair; Dr Anchali Krisanachinda, Thailand, Secretary; Dr C.M. Pathak, India; Dr Wynand J Strydom, S Africa; Dr Ye-Cho Huang, PR China; Dr Adel A. Mustafa, USA; Dr Ana Cecilia Pedrosa de Azevedo, Brazil.

2006-2009

Dr Anchali Krisanachinda, Thailand, Chair; Dr Cornelius Lewis, UK, Secretary; Dr HJ Kim, S Korea; Dr C.M. Pathak, India; Dr Ana Cecilia Pedrosa de Azevedo, Brazil; Dr William Rae, S Africa; Dr Adel Mustafa, USA.

Validation&Accreditation Panel: Dr Slavik Tabakov, UK, Chair; Dr Ervin Podgorsak, Canada; Dr Anchali Krisanachinda, Thailand; Dr Cornelius Lewis, UK; Dr Perry Sprawls, USA

2009-2012

Dr Maria do Carmo Lopes, Portugal, Chair; Dr Farida Bentayeb, Morocco; Dr Herman van Kleffens, Netherlands (EFOMP); Dr Pawel

Kukolowiczi, Poland (EFOMP); Dr William Rae, S Africa (FAMPO); Dr Chew Lip Teck, Singapore (SEAFOMP); Dr Paulo Roberto Costa, Brazil (ALFIM); Dr Rodolfo Alfonso Laguardia, Cuba (ALFIM); Dr Rabih Hammoud, Qatar (MEAFOMP); Dr Kalle Kepler, Estonia; Dr Perihan Unak, Turkey; Dr Diana Adliene, Lithuania; Dr Maria Ester Brandan, Mexico

Validation&Accreditation Panel: Dr Slavik Tabakov, UK, Chair; Dr Ervin Podgorsak, Canada; Dr Anchali Krisanachinda, Thailand; Dr Cornelius Lewis, UK; Dr Perry Sprawls, USA

Medical Physics at ICTP – The Abdus Salam International Centre for Theoretical Physics, Trieste (from 1982 to 2010)

Luciano Bertocchi, Prof., Past Vice Director of ICTP (bertocch@ictp.it)

Although at Abdus Salam ICTP there is no permanent Research Activity in the field of Medical Physics, a very vigorous training activity takes place here in the period covering the 30 years from 1982 to 2011. It started with an International Conference in the year 1982 and the most recent one is the College on Medical Physics in September 2010. It is therefore proper to review this activity in some detail.

In the year 1982, due to the initiative and the enthusiasm of the late Giorgio Alberi, the ICTP hosted an International Conference on the Applications of Physics to Medicine and Biology, which saw the participation of 177 scientists. It was followed in 1983 by the Second International Conference on the Applications of Physics to Medicine and Biology, which had an even larger participation: 259 scientists. At this time Giorgio Alberi was already severely ill, but he insisted on being present at the Conference. He left us a few weeks later.

The success of these conferences, and the need of developing Medical Physics also in Third World countries, convinced ICTP that it was the right time to expand its training activities to include the field of Medical Physics. A first workshop on Medical Physics was organized in the same year, 1983, where the number of scientists from developing countries had already reached the figure of 33.

Two more short workshops on Quality Control in Medical Physics X-Ray Diagnostic Equipment followed in 1985 and 1986, organized by Dr. Anna Benini.

But it was only in the year 1988, with the expansion of the training activities of the ICTP to include a large number of scientific areas that a full-fledged College in Medical Physics, of a 4-week duration and with the participation of 68 scientists from developing countries, was organized. Since the beginning, the topics were addressed to Medical Imaging, Quality Control and Radioprotection. This College started a regular series of Colleges, in 1992 and 1994. The key names in these first Colleges are the ones of John Cameron (USA), Sergio Mascarenhas (Brazil) and Anna Benini (Italy and IAEA), who organized and directed the Colleges.

In the years in between the Colleges, other International Conferences were held, as "Giorgio Alberi Memorials"; during these Conferences, special prizes for the best research papers were awarded to scientists from developing countries.

Special attention should be given to the two International Conferences on the Applications of Physics to Medicine and Biology, held in 1992 and 1996. The one of 1992, devoted to the Advanced Detectors for Medical Imaging, was held in the week immediately after the College, giving the opportunity to the scientists from the Third World who had attended the College, to participate in an International Conference; the one of 1996 was also held in conjunction with the College on Medical Physics, and at the same time it hosted the Conference of the EFOMP (European Federation of the Organizations of Medical Physics) and of the AIFB (Italian Association of BioMedical Physics). This modality of having an International Conference linked to a training College was continued later in 2004, and repeated also for the next College in 2008.

The year 1994 saw the involvement of the International Atomic Energy Agency (IAEA) in the activities of the ICTP in Medical Physics; Anna Benini (who had, in the meantime, joined the Agency) organized together with the IAEA a Training Course on Dosimetry and Dose Reduction Techniques in Diagnostic Radiology. (This involvement of the IAEA continued also in the subsequent years, and especially in the College of 1999, which was held in conjunction with a Workshop on Nuclear Data for Medical Applications).

The College of 1996 (held in conjunction with the V-th International Conference) saw for the first time the presence of Perry Sprawls (USA) among the College Co-Directors; Professor Sprawls was to be a central figure in the subsequent Colleges. He is a scientist with a deep knowledge of all the aspects of Medical Imaging and an excellent organizer; but he is also a person of an unusual dedication to the promotion of Medical Physics. In all the Colleges he Co-directed (in 1999, 2002, 2004, 2006, 2008, and 2010) he donated to every participant in the Colleges a copy of each of his two books, on Medical Imaging and on MRI.

The activities of the Centre entered in a new dimension around the end of the century, when ICTP joined the EMERALD/EMIT project (led by S Tabakov). **EMERALD** - **E**uropean **ME**dical **RA**diation **L**earning **D**evelopment -, followed later by **EMIT** - **E**uropean **M**edical **I**maging **T**echnology Training - are two web based education and training packages, covering diagnostic radiology, nuclear medicine, magnetic resonance tomography, ultrasound and radiotheraphy. The importance of this project can be judged by the fact that in December 2004 the EMIT project received the first ever European Union "Leonardo da Vinci" award. This project continued with the EMITEL(led by S Tabakov), which developed Medical Physics Reference Materials – the first Medical Physics e-Encyclopaedia and Multilingual Dictionary (this project also included ICTP as a collaborator).

The materials of EMERALD/EMIT project, developed by a consortium that included ICTP, were used as training material in all Colleges held in after 1999, and each participant received a free copy of the CD's containing these materials. For these Colleges the team of College Co-Directors consisted of Perry Sprawls (USA), Slavik Tabakov (UK) and Anna Benini (Italy and Denmark), joined later by Franco Milano (Italy) and George D Frey (USA).

To discuss the EMERALD and EMIT project, two preparatory International conferences in Medical Physics Training were organized at the ICTP in 1998 and in 2003. In 2008 ICTP also hosted of the EMITEL e-Encyclopaedia International Conference.

The Colleges in 1999, 2002, 2004 were mainly devoted to Medical Imaging and to Radiation Protection; the 2004 College was followed by the Fourth International Workshop on Medical Applications of Synchrotron Radiation (in collaboration with the Trieste Synchrotron Radiation facility ELETTRA), and again the participants of the College had the opportunity of attending an International Conference. This International Workshop was followed in 2005 and 2006 by three specialized workshops on Synchrotron Radiation Imaging. The 2006 College included also a fourth week on Radiation Therapy organized by Franco Milano (Italy) with help from IAEA.

During the last several years IAEA launched a vigorous programme of cooperation with the ICTP, organizing a number of Joint Workshops and Schools. Several of them were in the area of Medical Physics. This way, six joint training activities have taken place so far:
2007 – a 1 week Workshop on Biomedical Applications of High Energy Ion Beams, and a 1 week Workshop on Nuclear Data for Science and Technology: Medical Applications
2008 – a 1 week Joint ICTP-IAEA Activity on Imaging in Advanced Radiotherapy Techniques, and a 2 weeks Joint ICTP-IAEA School on Quality Assurance in Radiotherapy with Emphasis on 3D Treatment Planning and Conformal Radiotherapy;
2009 - a 1 week Joint ICTP/IAEA Advanced School on Dosimetry in Diagnostic Radiology and its Clinical Implementation, and a 1 week Joint ICTP-IAEA Advanced School on Internal Dosimetry for Medical Physicists Specializing in Nuclear Medicine, etc.
The ICTP/IAEA programme is to continue in future - 3 more activities are planned for 2011. These are more specialized Schools, often complemented with practicals at the Trieste Hospital, through a cooperation agreement signed between the ICTP and the Hospital.

Also in 2007 ICTP took steps for exporting some of its activities. As a result the first Regional College on Medical Physics was conducted in Mumbai, India from November 12-23, 2007. The first week was devoted to The Physics and Technology of Medical Imaging and the second week to The Physics and Technology of Radiation Therapy with Dr Perry Sprawls and Dr S. D. Sharma as Academic Directors.

The College was sponsored and funded by the Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, and the Bhabha Atomic Research Centre (BARC), Government of India, Mumbai, India. Additional co-sponsors were the American Association of Physicists in Medicine (AAPM) and the Association of Medical Physicists in India (AMPI).

The Medical Physics Colleges during 2008 and 2010 were three weeks long and attracted some 300 applicants each. These continued the focus on Medical Imaging and Radiation Protection but with the added emphasis on the rapid growth of digital technology and its applications in medicine. These Colleges and the plans for the future Medical Physics Colleges included special practical training sessions at the Ospedali Reuniti di Trieste – Dept. Medical Physics (led by Dr Mario Dedenaro).

Since 2004 the Colleges include sessions to help the participants become more effective educators when they return to their countries. This is achieved through a Workshop with presentations from most countries taking part in the current College, plus classes on the learning and teaching process and the use of available educational resources, many of which are provided to the participants.

What has been described above is the 30 years experience of ICTP in the field of Medical Physics, in the form of "collective" teaching activities (Colleges, Conferences, Workshops, etc). However in all scientific areas (including Medical Physics) ICTP operates two other "individual" modalities: The Associate Members, and The Programme of Research and Training in Italian Laboratories (TRIL).

Associate Members are scientists from developing countries who are given the opportunity of spending periods of up to three months, three times during their appointment, to use the Centre's facilities and to conduct research (in the case of Medical Physics also joining research groups in Trieste, at the local hospitals or at the Synchrotron Facility ELETTRA). Currently more than 40 scientists have been appointed as Associate members in the field of Medical Physics.

The programme of Research and Training in Italian Laboratories (TRIL) gives experimental scientists the possibility to spend periods of time (up to one year) joining a group in an associate Scientific laboratory in Italy. 48 Italian laboratories offer this opportunity in the field of Medical Physics, and a total of 97 scientists were trained with 155 grants (some of the scientists received more than one grant).

The extent of what the ICTP has achieved in these 30 years in the field of Medical Physics can also be understood through a few figures: over 2000 scientists have taken part in the activities of the Centre (most from developing countries); more than 700 scientists have been trained through various modalities; each Medical Physics College includes young specialists from around 40 developing countries; many of these attendees have later started specific Medical Physics activities and courses in their own countries.

Education for Medical Physics: The IAEA Approach

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Introduction and Overview of Needs

The need for clinically qualified medical physicists is a recognised worldwide problem but is most acute in the developing nations. The contributing factors to this need include: the increasing complexity of both treatment and diagnostic radiation equipment, the raising of the expectations of good health care in all parts of the world, and the implementation of radiation safety standards.

This problem can be approached in two ways, by supporting existing medical physicists and by ensuring appropriate training to those preparing to enter the profession. Training for practicing professionals is given through workshops, training courses and fellowship programs. However the fundamental problem of delivering competent medical physics in a clinical environment can not be fully realised until the education of the entry practitioner is at a suitable standard. The IAEA has a long history of involvement in medical physics education with extensive training of existing medical physicists and more recently and fundamentally has been committed to raising the standard of the next generation of medical physicists through educational initiatives and support programs.

Academic Educational Programs

It is agreed that the ideal education for an entry level medical physicist should consist of appropriate academic qualifications at the postgraduate level, coupled with significant clinical training and the recognition of achievement to recognized standards. The recognition of medical physics standards is a common problem in almost all countries. Accreditation procedures, either national or ideally through professional organisations, are seen as vital in the education process.

For the practicing medical physicist continuing support through short courses, conferences attendance, access to the scientific literature etc should then follow.

From a world wide perspective the activities described above are far from being accomplished. A compilation of IAEA data for those countries with academic, clinical and accreditation processes shows that most African countries have no programme at all, while large areas of Asia, Europe and Latin America do not have clinical or accreditation programs.

The IAEA seeks to address these problems in a number of ways. Firstly the work of academic institutions is being supported; by the strengthening of on-going national MSc programs in Medical Physics, help in establishing new programs, development of syllabus material, and in the training of University staff through fellowship placements and the provision of laboratory equipment. This work has been very prominent in Latin America with IAEA support to national programs in Argentina, Colombia, Cuba, Mexico and Venezuela and with a large regional project including practically all countries in South America.

Recently a Handbook in Radiation Oncology Physics has been published that follows a previously published international Syllabus on Medical Radiation-Therapy Physics. This will be followed by similar activities in Diagnostic Radiology and Nuclear Medicine Physics. In the short period since the publication of the Oncology Handbook it has been adopted as the basis for MSc-level courses in Algeria, Cuba, Libya and is also used in a number of universities in Sweden, South Africa and Canada. However the success of these academic programs also requires good infrastructures in the recipient institution and national support through the recognition and remuneration of the work of medical physicists.

Clinical Education and Training

The issue of clinical education is often neglected, with the assumption that a seamless transition can be made from university education to clinical practice. Professional societies have however highlighted the inadequacy of this approach and have focused attention on the accreditation of clinical skills as an essential part of medical physics education. While short courses at the clinical level can be of help, properly directed clinical training requires a longer time frame to achieve the standards necessary for a competent clinical medical physicist. The IAEA currently has projects running in Asia, Africa and Latin America that include clinical training. The Asian project, for example, includes the development of an extensive set of clinical skills modules which will require support in the form of assessment of student progress and mentoring to gain the skill levels needed. The project in Latin America aims at developing guidelines on clinical training needs that are dependant on the academic level of the candidate, for application by universities, hospitals and regulators. Current project designs now include provision for the relevant professional societies, who are expected to assist with support through student assessment and mentoring, and to develop mechanisms of accreditation.

Continuing Education for Professional Development

The area of ongoing education and training and support of existing medical physicists has traditionally been a significant part of IAEA activity. Currently the IAEA trains around 200 physicists per year through short courses to upgrade knowledge and transfer skills. However it is recognised that there are also shortcomings with some courses being too short to give the required knowledge to the participant. Issues with the retention of clinical staff in developing countries, educated through IAEA support, are also of concern.

Summary and Conclusion

The IAEA is in the unique situation of being able to assist in both educational and training initiatives and also in clinically based activities. It has the capacity to make a response to the needs of developing countries. Inherent in this response is the need to appropriately define what a medical physicist is and to design activities that support the medical physics strengthening in developing countries.

The information in this paper is relevant to 2006.

Education/Training Activities and Plans of the AFOMP Education and Training Committee

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The ETC (Education and Training Committee) in AFOMP (Asia Oceania Federations of Organizations for Medical Physics) was established at the AFOMP Annual Council Meeting during the first Regional Conference AOCMP in Bangkok, Nov.14-15, 2001. The ETC Terms of Reference were suggested by Dr. Cheung Kin Yin, President of AFOMP at that time.

The first ETC members were appointed by the ETC Chairman K. Inamura, who also made an ETC Action Plan during 2002. The first ETC meeting was held in Gyeongju, Korea (2002). Later an AFOMP Workshop on Education and Training of Medical Physicists in Asia-Pacific Region was held at WC2003 in Sydney. Another Workshop was held by IOMP ETC and AFOMP ETC at WC2006 in Seoul. At this event, the status of education and training in AFOMP countries was discussed and compared with the situation in Europe and North America. The definition, role and responsibility of qualified medical physicists were discussed at this Workshop.

At the same time AFOMP and IAEA (officer Frank Pernicka) initiated an IAEA Regional RCA project titled "RAS6038 Strengthening Medical Physics in the Asia & Pacific Region". The project held its first meeting in Hong Kong (June 2002), and a liaison subcommittee was formed at AFOMP ETC. Later an Expert Steering Group Meeting was held in Mumbai, India (May 2005), and action plan in the field of radiation oncology was accepted.

According to the work plan of the RCA project, the following activities were scheduled to be carried out jointly by IAEA/RCA and AFOMP during 2003-04:

1) Development of common definition of qualified medical physicist in AFOMP countries
2) Identification of current status of medical physics in the region (including recommendation on medical physicists staffing)
3) Agreement on regional strategy for improvement and upgrading of technical standards and safe operating practices including QA/QC in key areas of medical physics
4) Agreement on a regional program for education and training (leading to future recognition as a qualified medical physicist)
5) Draft regionally harmonized standards on training in medical physics, and to circulate the draft for comments and approval by PC (Project Coordinators) and medical physics organizations in the member countries
6) Identification of method of national registration/1icensing and issue of recommendations on this subject to medical physicists
7) Assessment of existing professional standards as a component of action plan “Improvement and upgrade of safe operating practices and technical standards”

Following this an RCA project proposal for 2005-2006 (with budgetary proposal for AFOMP/ETC/RCA activities) were submitted to IAEA. In parallel Task Group Members were selected, nominated and recruited. As a possible solution a RAS6038 training program was developed and tested during 2007-2009. Other electronic textbooks such as EMERALD and EMIT [1] were recommended to be implemented as auxiliary materials to support the RCA program.

EMERALD and EMIT programs and resources were evaluated in Japan for the purpose of establishing a standard of MP training. The results were discussed at the Workshop “AFOMP Standard on medical physics training” held at the 3rd SEACOMP and 4th AOCMP in Kuala Lumpur.

The AFOMP ETC Symposium "Training of Medical Physics in Asia Oceania Region" was held at 5th AOCMP in Kyoto on Sept. 30 in 2005. The results of AFOMP ETC survey during 2004-2005 with questionnaire aiming to identify the targets and level of standardization of the education and training of medical physics in Asia and Oceania region were discussed at this Symposium . The survey included answers from 13 countries (out of 18 AFOMP member countries).

In this survey, the question related to the need of medical physics certification and/or licensing was answered with “yes” by 11 countries. Five countries revealed the fact that they have existing certification. Four countries set their highest priority to radiation oncology physics followed by both diagnostic imaging and nuclear medicine. The answers revealed that the highest priority should be for the standardization of the education and training in Radiotherapy physics. It was reconfirmed that clarification of definition, role and requirement of “qualified medical physicists” were essential for establishing certification/licensing system. Each country underlined the academic education and training program of real medical physics as the key requirement for scientific and practical development of the profession.

Another survey was carried out in 2008 [2]. In it we found:

(1) Number of patients per physicist varied significantly (from 250 to 800).

(2) Medical physicists shared a common work environment and faced similar difficulties.

(3) AFOMP had an important role by defining professional responsibilities and educational standard, by bringing physicists together and also by organizing conferences and workshops.

(4) A structured clinical training program was necessary to be implemented.

The results of the survey were reflected to Policy Statement No.1 and No.2 developed by PDC (Professional Development Committee) of AFOMP led by PDC Chairman Prof. Kwan Hoon Ng in 2009.

In addition to cooperation with IAEA/RCA project, AFOMP ETC wants to develop its own education activities based on financial supply from AFOMP member dues. Also education/training courses on physics in image quality assurance of CR, DR, MDCT and MRI are necessary (with the support of commercial companies). Six courses are now planned, and their number is expected to be increased to 12 courses in the next 5 years.

Although the countries have to solve their own problems internally, they need to have as a common target the increased number of qualified medical physicists, the high level of their services and the appreciation of their activities.

We have to use electronic materials such as EMERALD, EMIT and EMITEL for education/training and professional development of medical physics. Also a remote learning program should be developed to solve problems of procuring standardized machines even in provincial area of AFOMP. As a consequence the education and training should lead to further development of research programs.

The current Chairman of AFOMP ETC Prof. Kim Hee Jong is making every effort to advance AFOMP standards in education and training.

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The Teaching, Education and Accreditation Programs of the Australasian College of Physical Scientists and Engineers in Medicine

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The Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) is the professional body representing medical physicists and biomedical engineers in Australia and New Zealand. It was founded in 1979 and now has 450 members in 6 branches.

For a number of years it has offered examinations which lead to accreditation in Radiotherapy Equipment Commissioning and QC, Radiological Physics, Nuclear Medicine Physics, Radiation Protection, and Mammography QC. The candidates are provided with a syllabus and are largely required to undertake self-directed learning. Examination is usually by a combination of written, oral and practical examination.

In 2001/2002 government reports in Australia and in New Zealand on the provision of cancer services identified significant difficulties in the recruitment, training and retention of radiation oncology physicists in each country. This led to support for the establishment in 2003 of new Teaching, Education, and Accreditation Programs (TEAPs) by the ACPSEM. These programs offer three areas of specialization – radiation oncology medical physics, radiology medical physics and nuclear medicine physics.

The TEAPs are based around a 5-year program that consists primarily of the equivalent of one year of postgraduate academic education through an ACPSEM-accredited medical physics program, research and on-the-job clinical training. The academic education and research are often undertaken in fulfillment of an MSc degree in medical physics.

Most junior physicists (who are called ‘registrars’) enter the TEAP program on completion of a bachelor’s degree in physics at a reputable university. Others enter the program having already completed the equivalent of the required postgraduate academic education or with previous experience as a medical physicist for which they are given exemptions from some of the TEAP requirements.

The on-the-job training requires students to complete ‘modules’ of exercises etc. under the guidance of senior physicists. The training must be carried out in a clinical department that has been accredited by the ACPSEM. The actual ‘syllabus’ of subjects that must be covered in each TEAP is defined by the ACPSEM’s Specialty Group that deals with that specialization.

Graduating from a TEAP as a ‘qualified’ medical physicist requires a registrar to have successfully completed the postgraduate study, published research, completed training modules, kept a portfolio of their activities, and passed written, oral and practical examinations.

Currently there are six ACPSEM-approved MSc-level medical physics programs

- University of Canterbury (New Zealand)
- Queensland University of Technology (Australia)
- University of Wollongong (Australia)
- University of Adelaide (Australia)
- University of Sydney (Australia)
- Royal Melbourne Institute of Technology (Australia)

University accreditation is gained by a university by demonstrating that their medical physics degree covers all of the topics required by the ACPSEM to a sufficient level and that they have sufficient physical and staff resources to deliver a quality program. The required topics are

- Anatomy and physiology
- Radiation physics
- Imaging physics
- Radiotherapy physics

- Radiation protection
- Research and development skills

There is a requirement that clinical departments who wish to train registrars must be accredited by the ACPSEM. There are currently 19 clinical departments that are accredited in Australia and New Zealand. Most of these are radiation oncology departments. Departmental accreditation is achieved by presenting satisfactory written evidence to show that the department has sufficient equipment and experienced physicists to provide the required training. If they are unable to provide some of the necessary experience due to lack of equipment or expertise, then they are required to give evidence that they have an arrangement for their registrars to spend time in another department where this is available.

There are 32 registrars in the TEAP programs at present. Ten of these are in New Zealand and 22 in Australia. The majority (29) are in the Radiation Oncology Medical Physics TEAP while there are only two in the Radiology TEAP and one in the Nuclear Medicine TEAP at this stage. Each registrar is employed by a hospital; the contracts vary from hospital to hospital but are generally for a fixed term that covers the training period. There is the expectation that permanent positions will available for registrars on completion of their training as normal staff turnover and increasing service requirements create vacancies.

No registrars have completed their programs as yet. The first ‘graduates’ are expected at the end of 2007. These graduates are those that have received some exemptions for previous work and/or for completing relevant postgraduate study before commencing their TEAPs.

The programs have been well supported at national level by the Australian and New Zealand governments who have provided considerable funding to initiate the TEAPs. Within Australia, the support has varied from state to state with some (notably New South Wales) providing considerable support while others have been less so. At a hospital level, some clinical departments have embraced the

TEAPs with enthusiasm while others see it as an additional burden for overworked staff and have been reluctant to be involved.

Developing and running the TEAPs has been a huge challenge to the ACPSEM. It has only been possible with government financial support and determination by the ACPSEM. They are still evolving and a considerable amount of work is still required to get them fully functioning.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Australia

Population estimate, 2009	21,807,000
GDP per capita, 2009	US$ 37,298
Medical Physicists in Society, 2009	~500

New Zealand

Population estimate, 2009	4,306,400
GDP per capita, 2008	US$ 30, 030
Medical Physicists in Society, 2009	76

Medical Physicists Education in P.R.CHINA

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Present Status of Medical Physics in China

There are about 3,300 physicists being involved in research, teaching and working in different areas relating to medicine. Over 1,500 of them are working in medical universities and colleges teaching physics to medical students and doing research in medicinal-oriented research projects. Approximately 400 are involved in universities and colleges doing project-based research related to medicine. The remaining 1400 of them are working in hospitals and clinics as clinical physicists in radiology, nuclear medicine, and radiation oncology. Some of these 1400 are involved in clinical-oriented project research & manufacturer-sponsored project development. The subjects include medical radiation physics, medical imaging physics (radiology and nuclear medicine), medical laser physics, medical biological physics, bio-medical information physics, computer applications to medicine, clinical engineering, and medical physicist's education, etc..The professional organization of medical physicists in mainland China is called Chinese Society of Medical Physics, which was founded in 1981, and became an IOMP member in 1986.

Present Status of Hospital Physicist Training in China

There is so far no systematic training programs for medical physicists recognised by the Educational Ministry of the central government. However, clinically oriented medical radiation physicist training courses are available, like post-graduated students on-site training programs being carried out in major hospitals for a period of 6~12 months; 4 Years under-graduated medical physics student training programs; short-term intensive workshops and training courses running for a period of 2~4 weeks on specific therapeutic and diagnostic techniques and physics, such as CT/MRI/PET courses, 3DCRT & IMRT courses, TBI technique, SRS(SRT) technique, etc. since late

1970, because of urgent needs in hospitals and clinics. In recent years, programs of training medical physicists for B.S., M.S., and Ph.D. degrees have been established in following universities: Peking Union Medical Colleage Beijing, Qinghua & Beijing University Beijing, Wuhan University Hubei Province, Shiquan University Shiquan Province, Nanjing Aeronautics & Astronautics University, Taian Medical College, Shandong Province, etc.

Big Demands of Medical Physicists in Chinese Radiation Oncology

In contrast with only 80 medical radiation physicists working in fewer than 264 radiation oncology centers in the fall of 1986, there were 1181 medical radiation physicists scattered over in 951 radiation oncology centers by the end of 2006. The gap between market demands and number of available qualified medical physicists is still huge. Based on the number of radiotherapy units (LA, Cobalt, Afterloader) the number of radiation physicists needed increased from 363/80 (283 deficit) in 1986 to 2308/1181(1127 deficit). The demand becomes even larger if one therapy unit needs at least one radiation physicist as recommended by WHO and IAEA as China is still a developing country.

Problems and Solutions

The big gap between the market demands and the available numbers of qualified medical physicists is due to the following reasons: there were not enough number of graduate programs for training medical physicists; the current programs do not meet common standards as lacking qualified lecturers and clinical practice opportunities, and few of the programs have a complete set of courses. Among the medical physicists who have already been working in the clinics, the professional competency for some is questionable because of poor educational background and training. This is because on the one hand there is no medical physics residency program, and on the other the title of Medical Physicist has not been officially recognized, that discourages greatly their work and impacts on their promotion. In order to solve the above mentioned problems, we are trying to seek policy support and to get professional recognition of medical physicist from authorities. At the same time a lot of efforts should be done to enhance education and training by setting up Medical Physics residency programs and more graduate programs in big centers, and for that a strict accreditation system needs to be set up.

Accreditation

There is a Shang Gang examination system administered by the Public Health Ministry since 1996 and executed yearly by the academic societies like Radiology, Radiation Oncology, Ultra-Sonic, Nuclear Medicine, etc. which are affiliated with the Chinese Medical Association. This examination system is designed only for those people including physicians, medical physicists, technologists, medical engineers who are involved in using and operating LA (Linear Accelerator), CT/MRI, PET, etc.. All levels of personals, no matter what academic background they possess, have to take this examination for license. This system is nothing at all related to academic accreditations for medical physicists and for other professionals. In Xiangshan meeting held in 2004 in Beijing, we intended to set up in China a profession system for medical physicist working in hospitals and clinical-oriented research institutes as a four-level system in parallel to physicians: Assistant Medical Physicist; Medical Physicist; Associate Professor of Medical Physics; and Professor of Medical Physics. To qualify, one has to meet certain entrance academic requirements like BS, MS, PhD degrees of physics or related science, and to have a minimum period of time working in clinics, and to get a minimum score by paper examinations before promotion to one of the four qualified professional levels of medical physicist.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

People's Republic of China

Population estimate, 2008	1,338,612,968
GDP per capita, 2008	US$3,259
Medical Physicists in Society, 2009	400

Medical Physics Education and Training in Hong Kong, China

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1 INTRODUCTION

Medical physics service in Hong Kong was established in 1956 to provide radiation physics and radiation protection support for radiotherapy, diagnostic radiology and nuclear medicine services. Although not legally specified, medical physicists and the services they provide are considered indispensable in clinical services involving radiation for diagnosis and treatment of diseases. Medical physicists work directly with the medical staff in developing and providing safe and accurate clinical care. Because of their wide scope patient-oriented responsibilities, training of the medical physicists has been an important consideration in the development of physics services. This paper provides some background information on the education, clinical training and professional development systems for medical physicists in Hong Kong.

Physicist Profile

Physicist Category	Number (2006)
Physicist (Public Hospitals)	42
Physicist (Private Hospitals)	8
Physicist (Health/Regulatory)	9
Total	**59**

Medical Physics Specialty	Appx. Distribution
Radiotherapy Physics	55%
Imaging Physics	17%
Engineering Physics	13%
Health Physics	15%

2 EDUCATION

Medical physics education in Hong Kong is provided at the M.Sc. and Ph.D. level mainly by four universities (University of Hong Kong; Chinese University of Hong Kong; City University of Hong Kong; Polytechnic University of Hong Kong).

3 CLINICAL TRAINING

A Resident Physicist Training Programme was introduced in the Hong Kong public hospital system in 2004. The programme provides formal clinical training for Resident Physicists on a structured and systematic manner. Resident Physicists are recruited when physicist posts are available in the hospital system. The aim of the programme is to provide the most appropriate clinical training in the field of radiotherapy physics, imaging physics, and engineering physics to newly recruited Resident Physicists in public hospitals, such that at the end of the training, the trainees will be qualified for the posts of medical physicist who will be ready to undertake professional duties. The programme is being extended to accept enrolment from other hospitals.

3.1 The Training Programme

The Residency Training Programme consists of two parts. Part I training covers the theoretical and practical aspects of a wide spectrum of basic medical physics work in radiotherapy, imaging and engineering physics. Part II training is an in depth specialized training aiming to provide the Residents with the competency and capability of managing, either alone or with others, the clinical/practical duties and problems in one of the specialties of medical physics work, namely, radiotherapy physics, imaging physics, or engineering physics. The minimum duration of the training is two years, but in practice the programme usually takes three years to complete. Currently, there are six training centres in Hong Kong which can provide residency training. Since implementation of the programme, Five Resident Physicists have been recruited and enrolled in the training scheme. An annual enrollment of two trainees is expected for the coming five years.

3.2 Training Evaluation

Resident Physicists under clinical training are assessed internally by their training centres as well as externally by a professional body. Internal evaluation is based on log book assessment, practical demonstration and performance appraisal and is conducted by the trainers. External evaluation is conducted by Hong Kong Association of Medical Physics (HKAMP). Resident Physicists are required to pass two HKAMP examinations in order to complete the training programme. They are required to pass a written examination at the end of the Part I training programme and an oral examination at the end of the Part II training.

4 PROFESSIONAL CERTIFICATION & DEVELOPMENT

A professional certification scheme is operated by the HKAMP. Under this scheme, medical physicists practicing in radiotherapy physics, imaging physics, engineering physics and health physics can become certified in the specialties of their own practice by taking a two-part certification examination of their respective specialties. The examination is conducted by HKAMP and consists of a written and an oral examination. As a part of the certification system, certified medical physicists are required to meet the continued professional development (CPD) requirements of the HKAMP in order to remain certified.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Hong Kong Special Administrative Region of the People's Republic of China

Population estimate, 2008	7,008,900
GDP per capita, 2008	US$31,849
Medical Physicists in Society, 2009	55

Medical Radiation Physics and Medical Physicists in India

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1. Introduction

Medical Radiation Physics is an applied branch of physics that deals with the application of physical principles, concepts and methods to the diagnosis and treatment of diseases. Historically, medical physics has been concerned with the uses of ionizing radiation in radiodiagnosis and therapy. About three decades ago, medical physics activities were restricted primarily to the dosimetry of ionizing radiation. In the recent years, this concept has changed considerably and now the medical physicist is involved in physics of imaging, quality assurance of radiological equipment, administration of radiation protection, radiobiological modelling, biomedical instrumentation, bioelectrical investigations of brain and heart, thermograph, ultrasound, laser and nuclear magnetic resonance techniques.

2. Education and training

As shown in Table 1, there are ten regular M. Sc. Courses in medical radiation physics in India conducted by ten different institutions/ nine different universities. Broadly, M. Sc. Medical Radiation Physics Courses of India can be classified in two categories: (i) one year post M. Sc. Diploma in Medical/ Radiological Physics, and (ii) two years Master Degree Course in Medical Radiation Physics. Also shown in this table is the year in which each of these courses started, number of students taken per class at present and number of total students graduated so far.

2.1 Post M. Sc. Dip. R. P. Course in Radiological Physics of HBNI

The Radiological Physics & Advisory Division (Formerly DRP), Bhabha Atomic Research Centre (BARC), Mumbai, India initiated a one year Post M. Sc. regular training programme in Radiological Physics in 1962 in collaboration with World Health Organization (WHO). Until September 2010, 812 students (48 classes) including 17 from abroad and 180 sponsored by different institutions in India have successfully completed this training programme in Radiological Physics.

The foreign students sponsored by IAEA/WHO were from countries such as Burma, Nepal, Indonesia, Thailand, Philippines, South Korea, Tanzania, etc. In the initial stages of the course, experts from abroad were deputed by WHO and this helped in the development of the programme. Since 1973 the entire faculty for the course is from various Divisions of BARC and Atomic Energy Regulatory Board (AERB), India. The University of Mumbai recognized this programme in 1972 and began awarding the Diploma in Radiological Physics (Dip. R. P.) to successful candidates. The course has affiliation of Homi Bhabha National Institute, Mumbai, India since October 2007. Financial support from the Department of Atomic Energy, Government of India has made this programme a regular activity. Monthly stipend of INR 9300/- (Indian Rupees nine thousand three hundred) is being given to trainees except the sponsored candidates.

The minimum qualification for selection in the course is a M. Sc. (Physics) with more than 60% marks. The selection of the students for admission to the course is carried out through written screening as well as viva voce examination by the Physics Committee of BARC. Candidates who have successfully completed this course are eligible to work as a Medical Physicist and Radiological Safety Officer (RSO) Level-III [Medical/ Industrial] in medical as well as industrial and research institutions. The course consists of three terms (each of about 2 months duration), field training at various Divisions of BARC, one month clinical training at Tata Memorial Hospital, Mumbai and Radiation Medicine Centre, Mumbai and about 2 months clinical training at a reputed hospital outside Mumbai. Table 2 lists the name of subjects, teaching hours and examination scheme of the Dip. R. P. Course. The table presents course curriculum and examination scheme of Dip. R. P. / HBNI. The course has been revised and Semester System has been incorporated along with one year internship at well equipped medical institutions in the country. However, the revised syllabus and course modality is yet to be implemented.

Table 1: M. Sc. Courses in Medical Radiation Physics in India.

Name of the course	Institution/ University	Course duration	Starting year	Students taken per class	Students passed out
P. G. Diploma in Radiological Physics (Dip. R. P.)	Radiological Physics & Advisory Division, Bhabha Atomic Research Centre/ Homi Bhabha National Inst., Mumbai	1 year	1962	30	812
M. Sc. Medical Physics	Department of Physics/ Anna University, Chennai, Tamilnadu	2 years	1981	25	398
M. Sc. Radiation Physics	Calicut University, Calicut, Kerala	2 years	2001	08	30
M. Sc. Medical Physics	Bharathiar University, Coimbatore, Tamilnadu	2 years	2003	12	72
M. Sc. Radiation Physics	Manipal University, Manipal, Karnataka	2 years	2004	10	18
P. G. Dip. in Medical Physics (Dip. M. P.)	Jadavpur University, Kolkata, West Bengal	1 year	2007	10	25
M. Sc. Medical Physics	Punjab University, Chandigarh, Punjab	2 years	2007	10	18
M. Sc. Medical Physics	Bharathidasan University, Trichy, Tamilnadu, India	2 years	2007	10	20
M. Sc. Medical Physics	PSG College of Engineering/ Anna University, Tamilnadu	2 years	2007	15	22
P. G. Dip. R. P.	Osmania University, Hyderabad, Andhra Pradesh	1 year	2009	15	15

Table 2: Curriculum and examination scheme of Dip. R. P. Course.

Curriculum		
Sr. No.	Subjects of the course	Teaching hours
1.	Radiological Mathematics	65
2.	Radiation Physics	53
3.	Principles of Radiation Detection and Measurements	53
4.	Radiation Dosimetry	79
5.	Radiation Sources and their Applications	92
6.	Principles of Radiological Health & Safety	78

7.	Practical Work	90
8.	Field Training (Practical + Clinical)	490
Total Hours of Contact Training		1000
Examination Scheme		
Type of examination	Name of examination	Maximum Marks
Internal	Terminal examinations (3 terms)	300
	Practical work	200
	Field work	200
University	Theory (6 Papers)	600
	Practical work	100
Grand Total		1400

2.2 M. Sc. (Med. Phys.) of Anna University

M. Sc. (Med. Phys.) at Department of Physics, Anna University was started in collaboration with Cancer Institute, Adyar, Chennai, India. Different aspects of Medical Physics are being taught at the Cancer Institute by qualified faculty members both in Physics and Radiotherapy. Subjects like Mathematical Physics, Microelectronics and Instrumentation, Quantum Mechanics, Biophysics and Non Ionizing Radiation Physics are taught at the Physics Department of Engineering College, Anna University.

This course has been offered since 1981 and as of now 398 Medical Physicists has been trained. About 10% of these Physicists are employed abroad and the rest are employed in various centers throughout India. The eligibility for admission to the course is B. Sc. in Physics with Chemistry and Mathematics as ancillary subjects. The duration of the course is 2 years, consisting of 4 semesters. In the last semester, a project is carried out by the student. In addition, the students undergo a two week orientation course in medical physics and radiation safety and appear for the Radiation Safety Officer (RSO) Level-III Certification Examination conducted by Radiological Physics and Advisory Division of Bhabha Atomic Research Centre, Mumbai. Holding RSO Level-III certificate enables the students to work as an RSO if nominated by the employer and approved by the national regulatory authority, the Atomic Energy Regulatory Board. List of the subjects taught during the four semesters including the elective subjects are given in Table 3.

Table 3: Semester details of the subjects taught at Anna University

Semester - I 1. Mathematical Methods in Physics 2. Electronics and Instrumentation 3. Quantum Biophysics 4. Non-ionizing Radiation Physics 5. Engineering Graphics & Workshop Practice 6. Electronics & Instrumentation Laboratory	**Semester - II** 1. Numerical Methods and computer programming 2. Anatomy and Physiology 3. Biochemistry 4. Radiation Physics I 5. Elective I 6. Biomedical Instrumentation Laboratory
Semester - III 1. Biomaterials and Characterization 2. Biomedical Instrumentation 3. Radiation Physics II 4. Elective II 5. Elective III 6. Diagnostic and Therapeutic Laboratory	**Semester - IV** 1. Elective IV 2. Elective V 3. Seminar and Viva-voce 4. Project work
Elective Subjects 1. Biological effects of radiation and other agents 2. Nuclear Medicine 3. Radiation Dosimetry and Instrumentation 4. Radiation Hazards Evaluation and Control 5. Medical Applications of Lasers 6. Industrial Radiography 7. Medical Imaging techniques 8. Ultrasonic in medicine 9. Environmental Pollution Control 10. Advanced Clinical Radiation therapy Physics (Since 2006): (i) Conformal Radiotherapy with Multileaf Collimator (MLC); (ii) Megavoltage Portal Imaging (MVPI); (iii) Intensity Modulated Radiation Therapy (IMRT); (iv) Stereotactic Radiosurgery and Radiotherapy (SRS/SRT); (v) Image Guided Radiation Therapy (IGRT).	

2.3 M. Sc. (Rad. Phys.) of Calicut University

The M. Sc. (Rad. Phys.) programme of two years duration (8 semesters) at Calicut University was started in 2001 in collaboration with Regional Cancer Centre (RCC), Thiruvanathapuram, India. Each semester has 4-5 theory papers and 2-3 practical subjects besides regular internal assessment. The course is structured to have about 4000 hours of contact education and training. The last four semesters are devoted to the clinical field training of students. During the course, each candidate conducts a project under the supervision of faculties one each from the University and RCC. The total marks of the examination including a theory paper, practical works, project work and viva voce examination is 1700. These students also undergo a two week orientation course at RP&AD, BARC followed by written and oral examinations for RSO Level-III certification. Eligibility for admission to the course is B. Sc. Physics with 50% marks in aggregate and with mathematics as one of the subjects. From 2006 onwards, selection of the candidates for the admission to the course is done through an entrance test. Table 4 shows the semester wise details for the first four semesters of the course. As per the current information, the university is not conducting this course on regular basis.

Table 4: Semester detail of M. Sc. (Rad. Phys.) Course of Calicut University.

Semester - I 1. Mathematical Methods in Physics, Statistics and Numerical Analysis (80 h)* 2. Basic Electronics (80 h) 3. Electromagnetic Theory and Optics (80 h) 4. Nuclear Physics and Basic Quantum Mechanics (80 h) 5. Introductory Radiation Physics (80 h) 6. Electronics - practical (70 h) 7. Atomic & Nuclear Phys - practical (70 h)	**Semester - II** 1. Basic Medical Sciences -Anatomy, Physiology, Biochemistry & Radiobiology (80 h) 2. Radiation Detection, Measurement and Instruments (80 h) 3. Radiation Safety, Hazard Evaluation and Control (80 h) 4. Radiation Sources and Equipment (80 h) 5. Clinical Radiation Dosimetry -80 hours 6. Radiol. Instrumentation - practical (70h) 7. Computer Applications - practical (70h)
Semester - III 1. QA & Calibration of Radiological Systems - (80 h) 2. Research & Industrial Applications (70 h) 3. Physics of Medical Imaging (80 h) 4. Nuclear Medicine (80 h) 5. Radiation Detection and Measuring Instruments - practical (60 h) 6. Medical Imaging - practical (40 h) 7. Radiotherapy Dosimetry - practical (40 h)	**Semester - IV** 1. Physics of Radiotherapy (90 h) 2. Radiotherapy Planning (70 h) 3. Modern Trends in RT (60 h) 4. Radiotherapy Planning and Dosimetry - practical (60 h) 5. Quality Control, Acceptance Testing and Calibration of Radiological equipments – practical (40 h)

*number of teaching hours

2.4 M. Sc. (Med. Phys.) of Bharathiar University

The two-year (4 semester) M. Sc. (Med. Phys.) Course at Bharathiar University, Coimbatore began in 2003 in collaboration with GKNM Cancer Hospital, Coimbatore. Semester details of the course are given in Table 5. As can be seen from table, the first three semesters contain four theory papers and a practical paper while the fourth semester contains two theory papers and project. Each of these theory and practical papers carry 100 marks and the project carries 200 marks making the total of the course 1900 marks. During the third semester, the students undergo a one-month clinical training at GKNM Hospital, Coimbatore. The students also attend a two- week orientation programme and RSO Level-III certification examination conducted by RP&AD, BARC. Eligibility for admission to the course is a B. Sc. in Physics with Mathematics. The selection of candidates for admission is by entrance tests applying reservation policy of the state (Tamilnadu) government.

Table 5: Semester details of M. Sc. (Med. Phys.) Course of Bharathiar Univ.

Semester - I Paper I - Non Ionizing Radiation Physics, Lasers and Ultrasound in medicine Paper II - Fundamental Radiation Physics Paper III - Microelectronics and Instrumentation Paper IV - Numerical Methods and computer Programming Practicals - Electronics and Instrumentation Lab	**Semester - II** Paper V - Anatomy and Physiology Paper VI - Radiation Physics I Paper VII - Biomedical Instrumentation Paper VIII - Radiation Generators and Detectors Practical - Medical Physics Lab I
Semester - III Paper IX - Medical Imaging Technology Paper X - Rad. Hazards Evaluation and Control Paper XI - Radiation Biology Paper XII - Radiation Dosimetry Practicals - Medical Physics Lab II	**Semester - IV** Paper XIII - Nuclear Medicine Paper XIV - Advanced Physics of Radiation Therapy Project - Project Work and Viva Voce

2.5 M. Sc. (Med. Rad. Phys.) of Manipal University

The Master of Science in Medical Radiation Physics Course of two years duration (4 semesters) at Manipal University, Manipal began in 2004. This institution has advanced hospitals with well equipped radiotherapy centre. Candidates desiring admission to the Course should have B. Sc. with Physics as the major subject with 50% marks in aggregate. The semester details of the course are given in Table 6. First semester contains five papers while the remaining three semesters contain four papers each. Students undergo clinical training for two weeks at different radiotherapy centres. In addition, the students undergo a two weeks orientation course and appear for the RSO Level-III examination conducted by RP&AD, BARC, Mumbai.

Table 6: Semester detail of M. Sc. (MRP) Course of Manipal University

Semester - I 1) Basic Medical Sciences (Anatomy, Physiology) 2) Mathematical methods in Physics 3) Modern Physics and Electronics 4) Fundamentals of Computers and Computer Programming 5) Biostatistics	**Semester - II** 6) Radiation Physics: Radiation Quantities and Units. 7) Radiation Sources and Radiation Generating Equipments 8) Radiation Detection, Measurement and Instrumentation 9) Radiobiology and Radiobiological Basis of Radiotherapy
Semester - III 10) Physics of Medical Imaging 11) Physics of Radiotherapy. 12) Physics in Nuclear Medicine 13) Radiation Safety and Regulations	**Semester - IV** 13) Recent Advances in Radiotherapy 14) Modern trends in medical imaging 15) Clinical Radiation Dosimetry 16) Field Study

2.6 Dip. M. P. of Jadavpur / Dip. R. P. of Osmania University

The one year Post M. Sc. Diploma in Medical Physics Course of Jadavpur University, Kolkata was started in 2007 while one year Post M. Sc. Diploma in Radiological Physics Course of Osmania University, Hyderabad was started in 2009. Eligibility for admission in these two courses is M. Sc. in Physics. Dip. M. P. course of JU is conducted in collaboration with Advanced Medical Research Institution, Kolkata. Dip. R. P. course of OU is conducted in collaboration with MNJ Institute of Oncology, Hyderabad. The course content and modality of examinations of these courses are similar to Dip. R. P. of BARC/ HBNI. However, radiation safety in industrial and research applications of radiation are not the part of the syllabus of these two courses. Successful students of these two courses undergo a two weeks orientation course and appear for the RSO Level-III examination conducted by RP&AD, BARC, Mumbai. However, successful candidates of these two courses are eligible to be nominated as RSO-III for medical institutions only. Table 7 shows the course content of Dip. M. P., Jadavpur University.

Table 7: Course content of Dip. M. P. Jadavpur University, Kolkata

(i) Radiation Physics	(vii) Applications of radioisotopes in medicine

(ii) Radiation Chemistry	(viii) Radiation hazard evaluation and control
(iii) Radiation Biology	(ix) Exhaustive Experiments
(iv) Electronics and Instrumentation	(x) Demonstrations
(v) Statistics	(xi) Visit to Hospitals
(vi) Computational methods	(xii) Training in the clinical situation

2.7 M. Sc. Med. Phys. of PSG/ Bharathidasan/ Punjab

M. Sc. Medical Physics course of PSG College of Engineering, Coimbatore; Tamilnadu is affiliated to Anna University (AU), Chennai and hence course content, examination schedule, eligibility for admission and passing criteria for this course is similar to M. Sc. Medical Physics Course of Department of Physics, AU, Chennai. The course at PSG is conducted in collaboration with GKNM Hospital, Coimbatore. M. Sc. Medical Physics course of Bharathidasan University (BU) is also to M. Sc. Medical Physics course of Bharathiar University in almost all the aspects. The M. Sc. Medical Physics course of Punjab University is also similar to two years courses of other universities of India. This course is conducted in collaboration with Department of Radiotherapy, Post Graduate Institute of Medical Education and Research, Chandigarh. Successful candidates of these courses undergo two weeks orientation cum certification programme of RPAD, BARC, Mumbai. The certified RSO of these institutions are eligible to be nominated as RSO Level-III for medical institutions only.

3. Status of Profession

The Medical Physics profession in India is well recognized since 1962. The medical physicists trained at different centres in India are recognized by the national regulatory Authority, AERB as well as by Medical Council of India. About 800 medical physicists are working at different hospitals in the country. The majority of medical physicists are working in radiotherapy departments while a few are working in radiodiagnostic and nuclear medicine departments. Salary level for the physicists is also very good in India. More than 200 medical physicists graduated from the medical physics training programmes of India are working in different parts of the world and among them some are holding very high academic and administrative positions.

4. New Professional Developments

The country's medical physics programme is sufficient in itself to produce good quality well trained professionals. However, India also participates in a number of programmes conducted by different world bodies like IAEA, ICTP, WHO, ESTRO, AAPM, etc for continuous professional development of the medical physicists. India is one of the active members of IAEA/RCA project "Strengthening Medical Physics through Education and Training. At least one year internship in well equipped medical radiation institutions for academically qualified medical physicists has been made a mandatory requirement recently by AERB of India. In addition, Association of Medical Physicists of India (AMPI) has recently launched its academic and certification wing (College of Medical Physics of India, CMPI) for conducting education and certification of medical physicists. Trial certification programme was successfully conducted by CMPI in 2010 where 11 candidates participated in written and oral examinations and 10 of them have been declared successful. The CMPI certification is now conducted as a regular programme.

5. Projected Needs of Medical Physicists in India by 2020

Based on the recent cancer incidence rate in India about 1000 teletherapy equipments are required compared to the existing about 450. Ministry of Health, Government of India has proposed to add about 100 teletherapy machines for Cancer Control in the coming five years in Government run hospitals. In addition, about 15 teletherapy units are installed per annum in private hospitals/ clinics. Considering the above plans, about 500 additional medical physicists will be required. As can be seen from the data in Table 1, about 150 medical physicists are trained per annum in the country. So in the next ten years about 1500 trained medical physicists will be available. This indicates that the existing programmes in medical physics in India are sufficient to fulfil its requirement by 2020. A few medical institutions including Regional Cancer Centres and universities are also in process of starting M. Sc. (Med. Phys.) Programme.

6. Acknowledgements

Contributions of Dr. S. Ganesan, Professor, Anna University, Chennai; Dr I. S. Balakrishnan, Chief Medical Physicists, Cancer Institute, Adyar, Chennai; Dr. (Mrs.) Priyadarshini Rajguru, Medical Physicists, Cancer Institute, Adyar, Chennai; Dr M Musthafa, Lecturer, Department of Physics, Calicut University, Calicut; Dr. V. Selvarajan, Professor and Head, Department of Physics, Bharathiar University, Coimbatore; Dr. Balakrishnan, Lecturer, Department of Physics, Bharathiar University, Coimbatore; Dr J G R Solomon, Chief Medical Physicist, Manipal University, Manipal; and Dr Argha Deb, Coordinator, Dip. M. P. Jadavpur University, Kolkata; in preparing this write-up is gratefully acknowledged.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Republic of India

Population estimate, 2009	1,198,003,000
GDP per capita, 2008	US$1,017
Medical Physicists in Society, 2009	800

Medical Physics Education in Sri Lanka – MSc programme in Medical Physics of the Peradeniya University

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OBJECTIVES

The paper present information relevant to 2006, but the changes so far have not been significant. The objectives of the MSc Programme in Medical Physics of the Peradeniya University, Sri Lanka, are:

1. To educate and train personnel in Medical Physics including Diagnostic Imaging, Radiotherapy and Radiation Protection, so that they will have the basic knowledge to carry out the duties of a hospital physicist.
2. To provide opportunities for research in physics applied to medicine.
3. To provide supplementary courses for postgraduate training in some disciplines of medicine such as radiology, anaesthesiology etc.

THE PROGRAMME STRUCTURE AND DURATION

This is a full-time programme consisting of taught element and a research project. The taught element of the course is be conducted over a period of two semesters of 15 - weeks each *(during weekends and/or weekdays).*

The entire programme duration is about 15 - 18 months inclusive of three to six months for the research project. Satisfactory completion of a minimum of 25 credits of course work is required for the programme in addition to the six credits allocated for the full-time research project. Continuous attendance is compulsory during the period of research work.

In order to proceed to the research project the student has to obtain a Grade Point Average (GPA) of not less than 3.00 from the compulsory (23 credits) and optional courses (2 credits). If the student obtains a

GPA in the range 2.75 to 2.99, then he/she is eligible for the Diploma in Medical Physics but not the M.Sc. Degree. After successfully completing the courses and the research project, the student is eligible to receive the M.Sc. Degree.

Programme Summary

Course Code	**Course**	**Lecture hrs.**	**Practical hrs.**	**No. Credits**
Semester 1				
PH 531	Human Biology and Cell Biology	30	-	2
PH 532	Radiation Physics and Radiodiagnosis	15	-	1
PH 533	Nuclear Medicine I	15	-	1
PH 534	Radiation Protection and Radiotherapy	15	-	1
PH 535	Statistics	15	-	1
PH 536	Computing	15	-	1
PH 537	Introduction to Digital Electronic and Microprocessors	15	-	1
PH 538	Applications of Physics in Medicine	15	-	1
PH 539	Bioengineering	15	-	1
PH 540	Clinical Instrumentation	15	-	1
PH 541	Laboratory Course	-	45	1
Semester II				
PH 546	Radiation Protection	15	-	1
PH 547	Diagnostic/Rahiotheraphy Physics - I	30	-	3
PH 548	Radiotherapy /.Diagnostic Physics - II	30	-	2
PH 549	Radiotherapy /Diagnostic Laboratory	-	90	2
PH 550	Nuclear Medicine II	15	30	2
PH 551	Medical Electronics and Instrumentation*	15	-	1
PH 552	Computer systems and method*	30	-	1
PH 553	Biomechanics, Biomaterials and Rehabilitation Engineering*	15	-	1
PH 554	Computer Architectures and Artificial Intelligence*	15	-	1
PH 555	Ultrasound in Medicine*	15	-	1
PH 556	Non-ionising E.M. Radiations in Medicine*	15	-	1
PH 557	Clinical Tutorials and Demonstrations	-	30	1
PH 599	Research Project	(3 - 6 months)		6

**Optional courses: Students are required to obtain 2 credits from optional courses*

The minimum duration of the research project is 3 months. M.Sc. students are required to start thinking about their choice of project early during the 2nd semester, reading carefully through the full list of projects on offer, which are issued to them at that time. It is possible for students to propose topics of their own choice or to ask for a topic in an area not covered by those on the standard list. This, however, can only be done provided a suitable supervisor can be found and provided that the Supervisor and Head of Department agree that the new topic is feasible and appropriate facilities are available. The project is examined by an external examiner.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Democratic Socialist Republic of Sri Lanka

Population estimate, 2009	20,238,000
GDP per capita, 2008	US$1,971
Medical Physicists in Society, 2009	8

Status of Ionizing Radiation in Medicine in Nepal

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The use of ionizing radiation in medicine in Nepal has a long history starting about eight decades ago with the establishment of Tri-Chandra Electro-Medical Institute where the first x-ray machine was installed in 1923 by Dr. Rana And Dr. Asta Bahadur Shrestha. Since then tremendous development has taken place in the field of radiology and radiotherapy. In 1988, Bir Hospital introduced the first CT in Nepal. In the same year Bir Hospital introduced Nuclear Medicine in Nepal. In 1991 Bir hospital also introduced the first Radiotherapy unit with Tele Cobalt machine.

Recently, a tremendous development has taken place in the field of diagnostic radiology and Radiotherapy. Newer modalities are being introduced in major hospitals and latest radiological equipments are being imported. This quantitative increment may have a positive impact on the health service system of the country; but the lack of control is a serious problem. In Nepal, at present there are 4 Tele-Cobalt machines, 3 Linear Accelerators, 3 Simulators, 3 High Dose Rate (HDR) bracytherapy machines, One deep therapy machine, One Gamma Camera (SPECT), 10 Magnetic Resonance Imaging (MRI) machine, more than 30 CT Scanners and about 900 X-ray machines. There are about 330 qualified professionals (Radiologists, Radiation Oncologists, Medical Physicists/Radiation Safety Officers, Radiographers/Technologists, Radiation Therapists/Radiation Therapy Technologists, Nuclear medicine Physicians, Nuclear medicine Technologists). These are working in the field of diagnostic radiology, radiotherapy, nuclear medicine. There are two registered professional organizations.

Due to lack of radiation protection laws/regulations and infrastructures in Nepal, there is no legislative body or any Radiation act to set standards for radiation protection, radiological activities as well as any monitoring system. Official records of the exact number of the radiological facilities in operation also does not exist. Most of the radiation protection activities are carried out according to the individual knowledge of medical physicist following international guidelines, as there is no regulatory authority. Therefore there are no standards on radiation protection, as well as in the commissioning and decommissioning of radiation producing equipments. Over 90% of workers have never been monitored for their radiation exposure. Only the radiotherapy departments are surveyed and some medical physicists, mainly on a voluntary basis, take care of some diagnostic centres.

As per the report "Reviewing country and Regional Programmes RAS/0/057" from the IAEA fact-finding and programming mission to Nepal, the country should have at least 25 qualified Medical Physicist at present. But currently there are nine Medical Physicists, working in five different centres. There is no Medical Physics Program in Nepal, except some researches/thesis works carried out by the M.Sc (physics) students from Tribhuvan University, under the supervision of medical physicists.

Formal education in the field of radiology started in 1973 as a Certificate level Radiography course with the opening of Institute of Medicine in 1970. At present institute of Medicine is conducting two programs (Certificate and Bachelors) in Radiological Technology and a MD in Diagnostic Radiology. Likewise B.P. Koirala Institute of Health Science, Dharan runs a MD in diagnostic radiology and a Bachelor level course in Medical Imaging. The National Academy of Medical Science (NAMS) Bir Hospital has recently started MD courses in Diagnostic Radiology and Radiotherapy.

There are three registered professional organizations in the country, including Nepalese Association of Medical Physicist (NAMP) established in 2009. Recently Nepal became member of the

International Atomic Energy Agency (IAEA) and this will certainly support and speed up the creation of appropriate conditions

Problems:

1. Still no National Radiation Legislation for use of ionizing radiation in medicine.
2. Lack of national priority for developing quality assurance and radiation protection programs.
3. Lack of national priority for developing medical physics.
4. Lack of facilities to stop brain drain and stay longer in profession
5. Still no recognition of role/responsibilities of Medical Physicist.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Federal Democratic Republic of Nepal

Population estimate, 2009	29,331,000
GDP per capita, 2009	US$444
Medical Physicists in Society, 2009	10

Medical Physics Education in Pakistan-an Overview

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1. Introduction

Medical Physics is one of the main braches of applied physics which has seen tremendous advances over the last few decades. There are four main areas of medical physics namely Nuclear medicine, Radiology, Health physics and Radiation therapy. A physicist trained in medical physics can opt to work in any of the above mentioned fields [1, 2].

In Pakistan currently there are 13 cancer hospitals run by the Pakistan Atomic Energy commission (PAEC) in addition to these established in the private sector (Shaukat Khanum memorial cancer hospital in Lahore etc.). PAEC is also in process of establishing another 5 cancer hospitals in different parts of the country. A number of hospitals have also established their radiation oncology departments. In addition to these the demand is steadily increasing at the nuclear power plants (2 nuclear power plants are operating and another few are in construction and planning phases) and other radiation facilities [3]. Therefore the requirement of trained medical physicists has increased many folds in the country over the last few decades and is projected to increase further in near future. This paper describes the educational activities in the field of medical physics in Pakistan and the future prospects of medical physics as a profession in the country.

2. Medical Physics education history in the country

In normal university degrees medical physics is usually not offered as a major specialization, the number of institutions offering courses/training in medical physics is very limited. Nevertheless PAEC has been the leading organization in the filed of medical/health physics education. Centre for Nuclear Studies (CNS) now called Pakistan Institute of Engineering and Applied Sciences (PIEAS) since its inception in 1967 has been offering various types of courses in the field of radiation protection and medical/health physics [4].

The duration of health and medical physics courses in Pakistan has ranged from few weeks to 1 year postgraduate diploma in medical/health physics. Students holding masters degree in science were admitted to the diploma programme and after the completion of the course (either in health physics or medical physics) they were sent for an on job training. The short duration courses were offered for radiation technologists and other radiation workers.

3. MS Medical Physics programme at PIEAS.

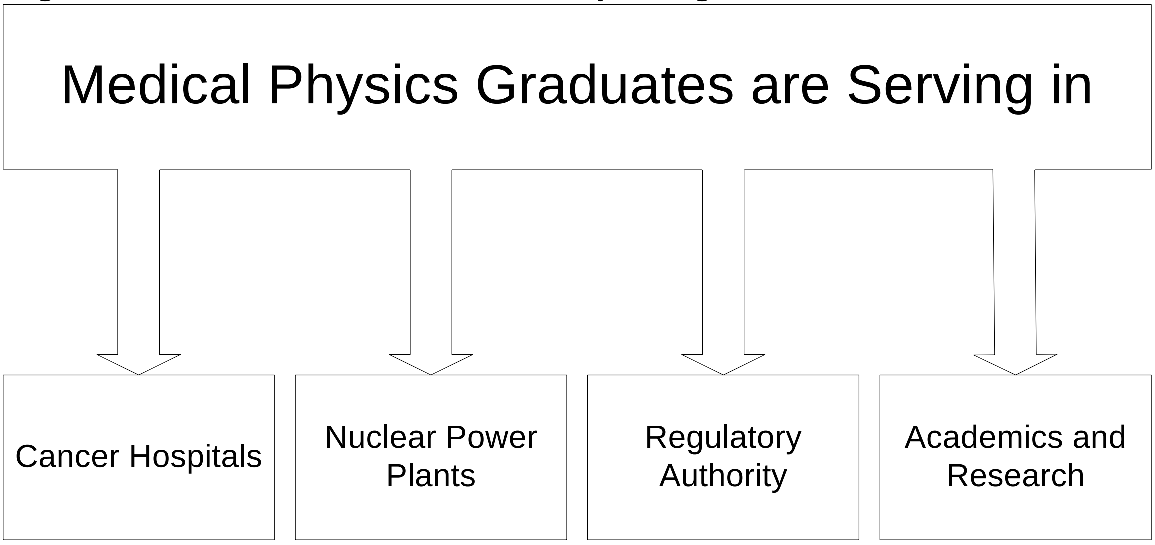
PIEAS has been ranked as the best engineering university in Pakistan by the higher education commission in the country [5]. It currently offers 9 Master (MS level) programmes (table 1); in addition to these all the departments offer PhD programmes. Currently there are more than 100 faculty members at PIEAS (40 faculty members are foreign qualified PhD's). The faculty is involved in a wide variety of research and this has been widely acknowledged at the national and international level.

Table 1: MS courses offered by PIEAS

Name of the course	Department Name
1. MS Medical Physics	Department of Physics and Applied Mathematics.
2. M.Phil. Physics	Department of Physics and Applied Mathematics.
3. MS Process Engineering	Department of Chemical and Materials Engineering.
4. MS Mechanical Engineering	Department of Mechanical Engineering.
5. M.Sc. Nuclear Medicine	Department of Medical Sciences.
6. M.Sc. Radiation & Medical Oncology	Department of Medical Sciences.
7. MS System Engineering	Department of Electrical Engineering.
8. MS Nuclear Engineering	Department of Nuclear Engineering.
9. MS Materials Engineering	Department of Computer and Information Sciences.

With the growth in the number of cancer hospitals, diagnostic radiology facilities and nuclear power plants the role of medical physicist has assumed more importance and a need was felt for highly qualified workforce. Therefore with the assistance and advice of IAEA the MS in Medical Physics was launched in autumn of 2001. It was the first MS level Medical Physics course in the country offered by Department of Physics and applied Mathematics (DPAM) at PIEAS. This programme is run in collaboration with the allied hospitals (NORI) and Pakistan Institute of Nuclear Science and Technology (PINSTECH). So far about 100 students have graduated and are serving at different organizations (figure 1). The number of students enrolled presently in medical physics programme is 24.

Figure 1: Placement of Medical Physics graduates



3.1 Course structure of the MS Medical Physics Programme

It is 70 credit hour 2 year programme with 5 semesters. The first three semesters comprise of course work and the last 2 semester are reserved for Thesis project and clinical attachment at the allied hospitals respectively. Before the start of 1st semester a Zero semester is offered as a refresher course because the students usually come from diverse background and may lack in few subjects. Semester wise course break up of the programme is given in table 2-7.

Table 2: Zero Semester courses

Zero Semester		
Sr. No	**Name of the course**	**Credit hours**
1	Elementary Mathematics	04
2	Introduction to Nuclear Science and Technology	04
3	Computing Fundamentals	04

4	English	04

Table 3: Semester 1 courses

Semester 1		
Sr. No	**Name of the course**	**Credit hours**
1	Radiation Detection and Interaction	04
2	Applied Mathematics	03
3	Computers in Medical Physics	03
4	Anatomy Physiology and Medical Terminology	03
5	Introduction to Nuclear Physics.	03

Table 4: Semester 2 courses

Semester 2		
Sr. No	**Name of the course**	**Credit hours**
1	Biophysics and Radiation Biology	03
2	Physics of Radiology-I	03
3	Physics of Radiotherapy-I	03
4	Physics of Nuclear Medicine.	03
5	Radiation Protection and Health Physics	03

Table 5: Semester 3 courses

Semester 3		
Sr. No	**Name of the course**	**Credit hours**
1	Physics of Radiology-II	03
2	Physics of Radiotherapy-II	03
3	Quantitative Analysis and data processing	03
4	Special Topics in Medical Physics	03
5	Radiation Detection and Protection lab	03

Table 6: Semester 4 courses

Semester 4		
Sr. No	**Name of the course**	**Credit hours**
1	*Thesis Project	12

*The thesis projects are carried out at the allied hospitals, PIEAS and PINSTECH

Table 7: Semester 5 courses

Semester 5		
Sr. No	**Name of the course**	**Credit hours**
1	*Clinical Attachment	12

*The clinical attachment is carried out at the allied hospitals and PINSTECH

The course work comprises of 15 courses. The faculty at PIEAS and faculty members from the allied hospitals like Nuclear Medicine Oncology and Radiotherapy Institute (NORI) and PINSTECH contribute in the delivery of these courses.

3.1.1 Thesis/Research Project

Thesis projects are offered by the faculty in PIEAS and by various PAEC and private cancer hospitals. PINSTECH offers projects for the students who wish to specialize in Health physics. A project evaluation committee comprising of senior faculty members decides the allotment of projects, the department also assigns a Co-supervisor for each project. At the end of the research project the students are required to submit thesis based on the problem assigned to them. Thesis writing manuals are available to the students; however the department also offers help in this regard. Plagiarism and copyright are strictly discouraged and the department keeps strict vigil in this regard. Every student is required to sign a declaration of originality. The main research areas available to students are

- Mammography and X-ray.
- Radiation Dosimetry.
- Medical Imaging.
- Monte Carlo simulations.
- TLD and diode Dosimetry.
- Radiation therapy (Treatment Planning).

Additionally to submitting of a written thesis, the students also have to present their projects at an oral presentation in the department before the start of clinical attachment.

3.1.2 Clinical Attachment (Training)

The clinical attachment which is carried out at the hospitals and PINSTECH serves as an on job training in medical/health physics. The students are assigned to work under the supervision of senior medical/health physicist. At the conclusion of the clinical attachment students are required to submit a written report along with an oral presentation.

3.1.3 Facilities available at PIEAS for Medical Physics

A wide variety of facilities are available for students of medical physics, these include

- Radiation detection lab
- Treatment Planning room
- Gamma Camera
- Health Physics lab
- Medical Physics lab.

The experiments performed at Detection lab are as follows.

- NaI(Tl) Detector
- Attenuation Coefficient & Build-up factor
- Surface Barrier Detector
- BF3 Detector
- Characteristics of G.M Tube and measurement of half life

In the treatment planning room a Theraplan system is available for training the students about the various aspects of treatment planning. The department of Medical Sciences operates a gamma camera; this system is utilized to train students in the quality control of the gamma camera. The health physics lab provides the opportunity to study the various radiation monitors and decontamination procedures. The medical physics lab is equipped with a TLD system and a Diode system; both these systems are used for in Vivo Dosimetry. In addition ART phantom and Dosimetry set up is also available. In addition to these this lab has quality control kit for mammography and various other accessories.

4. Issues confronting Medical Physics education

Despite the rapid growth, medical physics education is still encountering a number of difficulties in the developing countries, some of these problems have been mentioned below briefly.

4.1 Lack of awareness about medical physics:

Being a relatively new field a number of students are unaware about medical physics and how to pursue a carrier in this filed and what to expect in terms of job security and financial benefits.

4.2 Lack of trained faculty:

Availability of trained faculty is a problem because of the limited number of Physicists involved in academics and also to the fact the rapid changes in the field over the last few years has increased the demands from faculty. Recently a number of faculty members have been sent abroad for higher studies and training which will improve the situation considerably.

4.3 Lack of Equipment/laboratories

Availability of the latest equipment in Radiation therapy, Diagnostic radiology and nuclear medicine is limited due to financial constraints; this does affect the quality of education and student training. Despite the financial constraints a number of PAEC hospitals are currently in process of upgrading the radiotherapy and radiology departments. This will help in the future training of the students.

5 Future Prospects of Medical Physics education in the country

The future prospects seems very promising as the government and academia both are eagerly embracing this profession, and the Pakistan nuclear regulatory authority (PNRA) has done reasonably well in promoting the need and role of medical physicist [6]. This growing awareness among the public and private sector would definitely lead to improvement and investment in the field. Also the possibility of residency programme in medical physics is being explored. The number of Medical Physicists going abroad for higher education and training is increasing as the higher education commission (HEC) is providing a number of scholarships and this would be a great value addition to the education of medical physics in the country. International technical assistance in the form of equipment and training from IAEA and other organizations is likely to increase.

6 Conclusions

The field of medical physics has grown steadily in the country and education/research facilities have improved significantly. However the need for enhanced cooperation and collaboration between various international bodies is stressed so as to divert more funds and technical expertise to the developing nations.

7 References

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3. Pakistan Atomic Energy Commission, P.O Box 114 Islamabad, Pakistan. www.paec.gov.pk
4. Pakistan Institute of Engineering and Applied Sciences, P.O Nilore, Pakistan (www.pieas.edu.pk)
5. Higher Education Commission of Pakistan. H-9, Islamabad. (www.hec.gov.pk)
6. Pakistan nuclear regulatory authority, Islamabad Pakistan. (www.pnra.org)

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Islamic Republic of Pakistan

Population estimate, 2009	180,808,000
GDP per capita, 2008	422
Medical Physicists in Society, 2009	~ 200

Medical Physics Education in Indonesia

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Introduction

Indonesia is still lacking highly trained medical physicists. Currently there are 38 medical physicists (full time) who work in 20 radiotherapy centres. By 2006 only 2 of these 28 medical physicists had master degree. By 2011 this number increased to 10 (working in 7 Radiotherapy centres). Almost all diagnostic radiology departments operate without a medical physics specialist (there are more than 6300 x-ray units in the country). Additionally there are uncountable numbers of ultrasound units in Indonesia. Several MRI are also available and commonly belong to the biggest hospitals. Therefore the need of medical physicists is obvious. One of the methods to produce medical physicists and to develop this field is to establish education that meet international standard.

Study Program

From 1985 a one year Medical Physics course for technologists is offered by the Physics Department, Faculty of Mathematics and Sciences, University of Diponegoro, in collaboration with Department of Health. Further this department introduced several medical physics modules as special topics in its curriculum for physics (undergraduate study). Nearly at the same time the Technical Faculty, Gajah Mada University, established a study program on Nuclear Technology, which also included medical physics content to its curriculum. Again, most of the students in this program are technologists/radiographers. Currently most medical physicists who serve in radiotherapy centres are alumnae from these two universities.

During 1998 the Physics Department, Faculty of Mathematics and Sciences, University of Indonesia, supported by Indonesian Nuclear Energy Agency, opened an undergraduate program in Medical Physics and subsequently a graduate program was opened in 2002. At present this is the only graduate program on Medical Physics in the country. An extended undergraduate program was also established in 2003. Most students in this extension program are either from technician/radiographer or alumnae diploma program in physics instrumentation. Activities of this extension program take place in the evening.

To prepare professional medical physicists, clinical training program in the form of internship is necessary together with the university degree . Therefore establishing such clinical residency program is one of the priorities in the country. The preparation of supervisors for this clinical training is in progress. Since there is no medical physicist supervisors at the hospital in the country, candidates are trained overseas, at the radiotherapy centres that have supervisors and better facilities. One young staff member has been trained at Radiotherapy Department, Westmead Hospital, Australia for 10 months and at Tata Memorial Hospital for 2 months (with IAEA fellowship). Another 2 young staff members were trained at NCC (National Cancer Centre), Singapore, also with IAEA fellowships.

Initially it was hoped that in 2007 clinical training in radiotherapy could be initiated. Although 6 –12 months training for the trainers was not enough, we will start to establish clinical training with this condition and shall use our experience to further develop this residency program. The same plan will be used for the development of medical physics for diagnostic and nuclear medicine

In 2007 there was an IAEA-RCA (Regional Cooperative Agreement) meeting in Bangkok, Thailand which disseminated information about Clinical Training for Medical Physicists in the field of Radiotherapy/Radiation Oncology. The guideline draft for this clinical training was already prepared comprehensively by that time and was published as IAEA Training Series No. 37 in 2009. In reference with this guideline, Indonesia was not able to run clinical training, as we did not have supervisors and residence candidates who fulfilled the recommendation requirements. After waiting for a long time, we hope that in 2011 we can start to run clinical training for medical physicists in the field of Radiotherapy, as well in Diagnostic Radiology (even with minimum man power). The guideline draft for clinical training for medical physicists specialising in Diagnostic Radiology has been introduced at the IAEA-RCA meeting in Manila, Phillipines, 18-19 January 2010. Similar draft guideline for specialising in Nuclear Medicine has been informed in IAEA-RCA meeting in Dhaka, Bangladesh, 18-19 October 2010.

Together with the preparing qualified medical physicists, the improvement of medical physics services at the hospitals is paramount. To raise the knowledge of the staff involved in the field of radiotherapy, diagnostic and interventional radiology, and nuclear medicine, special workshops or schools were held. From 2007 to 2010 a number of collaborative Workshops were organised by the Physics Department, the Indonesian Medical Physicists and the Biophysicists Association, namely: 2 workshops in Radiotherapy, 1 workshop in Dosimetry, 2 workshops in Diagnostic and Interventional Radiology, and 1 workshop in Nuclear Medicine. All these workshops were sponsored by IAEA with expert missions.

Curriculum

Most curricula for undergraduate and graduate program are adopted from AAPM Report No. 79. The curriculum for the two programs is nearly the same, however the lecture materials for graduate program are relatively wider and deeper.

1. Undergraduate Program

Curriculum for under graduate in general consists of 5 group topics. The student can start to take these lectures after having 110 credits in basic Physics and Mathematics.

Table 2 Topics study in Medical Physics Undergraduate Program

No.	Group of topics	Topics	Credits
1.	Fundamental	Physics of Radiology and Dosimetry	2
		Health Physics and Radiation Protection	2
		Introduction of Radiation Biology	2
		Anatomy and physiology	2
		Biochemistry	2
		Medical Instrumentation	3
2.	Physics of Diagnostic	Introduction to X ray imaging and Nuclear Medicine	3
		Ultrasound and Magnetic Resonance Imaging	2
3.	Physics of Radiotherapy	Radiotherapy	3
		Treatment Planning and Quality Assurance	2
4.	Clinical topic	Medical Ethics and Clinical Radiology	2
5.	Special Topic	Biophysics	2
6.	Laboratory	Nuclear Physics Lab.	2
		Diagnostic Imaging Lab.	2
		Radiotherapy Lab.	2
		Introduction to Clinical Practice	2
		Total	**35**

2. Graduate Program

Since not all students come from the medical physics undergraduate program, the curriculum for graduate program has many elements identical with undergraduate curriculum. However the syllabi in graduate program are with more depth.

Table 2 Topics study in Medical Physics Graduate Program

No.	Group of Topics	Topics	Credits
1.	Fundamental	Physics of Radiology	2
		Dosimetry	2
		Radiobiology Application	2
		Anatomy and Physiology	4
		Medical Instrumentation	2
		Radiation Protection	2
		Advance Modern Physics	2
		Advance Electronics	2
2.	Physics of Diagnostic	Diagnostic Imaging I (X rays and Nuclear Medicine)	3
		Diagnostic Imaging II (Ultrasound and Magnetic Resonance)	2
3.	Physics of Radiotherapy	Radiotherapy	3
		Treatment Planning and Quality Assurance	2
4.	Special Topic	Biophysics	2
5.	Seminar		2
6.	Thesis		8
		Total	**40**

Laboratory and Equipment

To carry out laboratory work and research, the Physics Department collaborates with several hospitals and institutions such as Indonesia

Nuclear Energy Agency. There are 5 radiotherapy centres, 3 nuclear medicine centres, many radiology diagnostic centres (government and private) in Jakarta. Since 2007 IAEA has supported many equipment for education and research, such as several types of phantoms, TLD system, QA equipment for Diagnostic Radiology, 2D matrix dosimeters, Scintillation counting systems, etc.

Library

Initially the library was supported by IOMP. Step by step we added to the collection with new books. Journal of “Radiation Protection” and “Medical Physics” are received regularly with the assistance of IOMP. Currently the faculty uses also an E-library, so that students and staffs have access directly to more journals and books.

Lecturers

The Physics Department had only 3 lecturers with Ph. D degree. (one of them passed away in 2008). Currently we have also 4 part time lecturers with Ph. D degree, from other institutions, such as Indonesian Nuclear Energy Agency, Bandung Institute of Technology, and private sectors. Four high rank alumnae have been recruited as young staff members, and one of them is expected to achieve Ph.D degree this year. Other 3 higher rank alumnae are part time staffs, and they joined with Indonesian Nuclear Energy Agency and Radiotherapy centres.

We plan to stimulate our young staff members to get higher degree in order to fulfil the requirement to be lecturers and be able to be leaders in the development of Medical Physics in the country. We plan to run in future a doctorate program. This program will increase no only the number of PhD staff, but also the quality of research.

Program quality development

For MSc project students may choose title in the field of either Medical Physics or Biophysics. To meet international standards, 3 theses have been reviewed by an expert from overseas (Prof. Dr. K. Y. Cheung from Hong Kong), 6 graduates have been examined also by experts from overseas together with in-house examiners. The overseas examiners were Prof. Dr. Ng Kwan Hoong from Malaysia, and Wong Toh Jui, M Sc from Singapore. The three experts are active in AFOMP (Asia-Pacific Federation of Medical Physicists) and SEAFOM (South East Asia Federation of Medical Physicists). The result of this examination method is promising. One of the graduates was awarded as second best for his poster at AFOMP Congress on Medical Physics 2001, Kuala Lumpur, first best presentation at 3rd SEACOMP and 4th AOCMP 2004, Kuala Lumpur, Malaysia.

For several years we do not invite examiners from abroad due to lack of funds. However the quality control of education was supported by IAEA, with experts visits in 2007 and 2009 (especially for evaluating the program). The results stated that the program was on the right track, however it should be enhanced with more lecturers and more of practical work for the students. We deal with these problems step by step. In the mean time the students have strong motivations to develop and compete with students from other countries. This can be seen at many SEACOMP events where several students have received awards for either their posters or their presentations. Last year (2010) at the 8th SEACOMP, 6 out of 12 awards (6 in radiotherapy and diagnostic radiology posters, and 6 in radiotherapy and diagnostic radiology presentations) have been received by Indonesian students.

Alumnae

Table 4. Number of alumnae up to 2010

Program	No alumnae	Degree
Under graduate	109 (compared with 62 by 20006)	B Sc honor
Graduate	44 (compared with 15 by 20006)	M. Sc

Not all graduates work in the hospitals. Several of them joined other institutions such as vendors of medical equipment, Indonesian Nuclear Energy Agency, Nuclear Energy Regulatory Board, and Indonesian Institute of Science. The rest of them work with other government and private sectors.

Conclusion

The Physics Department, Faculty of Mathematics and Sciences, University of Indonesia has opened Medical Physics at undergraduate level in 1998, and at graduate level in 2002. Curriculum is adopted from AAPM Report No. 79. The equipment for education and research were funded by IAEA, while initially the library was supported by IOMP. To achieve a good standard, theses graduate students were initially examined by several experts from abroad. Alternatively, for quality control purposes, the program has invited IAEA experts. The number of alumnae is 109 persons from undergraduate program, and 44 persons from graduate program. Alongside with running these educational activities, the physics department contributes also in raising the knowledge of the existing medical physicists to improve their services at hospitals. Medical Physics in Indonesia is growing.

References

1. AAPM Report No. 79, Academic Program Recommendations for Graduate Degrees in Medical Physics, 2002.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Republic of Indonesia

Population estimate, 2009	229,965,000
GDP per capita, 2009	US$2,238
Medical Physicists in Society, 2009	40

Medical Physics Education in Malaysia

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There are two universities in Malaysia offering Medical Physics program at graduate level:

1. University of Malaya (Faculty of Medicine)
2. University Science Malaysia (School of Physics)

University of Malaya System

The Master of Medical Physics Program at the University of Malaya http://radiology.um.edu.my/mmedphy/ has the distinct privilege to be at present the only master program outside the British Isles to be accredited by the Institute of Physics and Engineering Science in Medicine (IPEM), United Kingdom. (2002-2012) http://www.ipem.org.uk/. The program and examinations are moderated by external examiners from the UK and USA.

Short curricula:

Semester 1	Credit hours
Anatomy and Physiology	4
Biostatistics	3
Computing and Medical Statistics	3
Applied Radiation Physics and Dosimetry	3
Radiobiology and Radiation Protection	3
Non-Ionising Radiation in Medicine	3
Semester 2	
Medical Imaging	3
Radiotherapy	3
Nuclear Medicine	3
Dissertation	12

Number of graduates in total

Year	Enrolment	Graduated
1998	5	n.a.
1999	5	5
2000	4	5

2001	4	3
2002	6	3
2003	6	5 (4 MS, 1 PhD)
2004	5	4
2005	3	6 (5 MS, 1 PhD)
2006	6	2

20+ Master of Medical Physics and 2 PhD Medical Physics

Innovative development of courses/programmes:

- Tele-teaching with Professor Perry Sprawls, Emory University and Dr Milton Woo, Toronto-Sunnybrook Regional Cancer Centre. http://www.jmir.org/2003/1/e3/

- Foreign and local expertise/lecturers were invited to give lectures to the students.
  Dr A Krisananchinda (Thailand), Dr A Perry (Australia), Dr Don McLean (Australia), Prof. Tomas Kron (Australia), Mr T Kadni (MNA), Dr Noriah Jamal (MNA), etc.

- The students are required to present their projects at local and regional scientific meetings. Some of them have published papers in peer-reviewed journals.

Practical training activities:
Clinical posting at radiology, nuclear medicine, and clinical oncology department.

Working perspective after graduation:
This program has trained and equipped students to take up professional positions in education, research and service orientated positions in hospitals, government agencies, laboratories, medical industry and nuclear technology industry.

Highlights/Achievements:

- External examiners include Prof. Larry DeWerd, Prof. Gary Fullerton, Dr. David Dowsett, Professor William Hendee, Dr. Joel Gray, Dr. Andrew Maidment, Dr David Sutton, Prof. Alan Perkins and Dr Roger Harrison.

- Accredited by Institute of Physics and Engineering in Medicine (IPEM) from 2002-2012.

Duration:
One calendar year (beginning July)

Medium of instruction:
English is used during lectures, tutorials and practical sessions

Entry requirements:
Good Bachelor of Science honours degree in physics or related fields from recognised universities or equivalent qualifications.

USM System:
Master of Science (Medical Physics)

Semester 1	Credit hours
Human Anatomy and Physiology	4
Radiation Physics	4
Dosimetry and Radiation Protection	4
Physics of Diagnostic Radiology	4
Medical Physics Practical	4
Semester 2	
Nuclear Medicine and Radiotherapy Physics	4
Ultrasound and Magnetic Resonance Imaging (elective)	2
Radiobiology and Radiation Chemistry (elective)	2
Research Project	8

Admission Requirement:
BSc. (Hons) in Physics or equivalent
BSc. in Physics or equivalent with several years of experience in a relevant field.

Duration:
Full-time Min/Max 12/24 months
Part-time Min/Max 24/48 months

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Malaysia

Population estimate, 2009	28,310,000
GDP per capita, 2008	US$8,118
Medical Physicists in Society, 2009	25

Medical Physics Education and Training in the Republic of the Philippines

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Introduction

The University of Santo Tomas (UST) is the only school in the Republic of the Philippines with a medical physics graduate program. The program was the result of a project proposal for technical assistance submitted by the Philippine government to the International Atomic Energy Agency in 1978. It was a joint project of the Department of Health through its Radiation Health Service and National Cancer Control Center, the Philippine Atomic Energy Commission, and the UST Graduate School. Although preparations began earlier, the MSc program was actually established in 1981.

Degrees Offered

Since 1981, the degree offered has been the **Master of Science in Applied Physics, major in Medical Physics**. This degree requires passing all the subjects, passing the comprehensive examination, and completion of a thesis. However, since most of the students work full time and study part-time, many fail to graduate. Work commitments prevent them from concentrating on their studies and from complying with the thesis requirement. Many of them were also employed as radiation oncology medical physicists before graduation and since they would be the only medical physicist in the facility, they were kept very busy at work with priority given to clinical medical physics work rather than research.

In 2004, a second degree was offered. This is the **Master of Medical Physics** (MMP). The MMP course is a non-thesis one. The requirements are the same as those of the original course, except for the thesis requirement. This requirement has been replaced by additional subjects.

Both master courses require four semesters and one summer term of study. The period covered is two years and one summer.

Subjects Offered

The curriculum for the MSc Applied Physics, major in Medical Physics, course is as follows.

FIIRST YEAR:

First Semester (13 units)

Introduction to Life Sciences	3 units
Radiation Physics	3 units
Physics of Diagnostic Radiology	3 units
Radiation Protection and Radiobiology I	3 units
Practicum in Diagnostic Radiology	1 unit

Second Semester (11 units)

Radiation Dosimetry	3 units
Radiation Protection and Radiobiology II	2 units
Physics of Nuclear Medicine	3 units
Physics of Ultrasound	2 units
Practicum in Nuclear Medicine	1 unit

Summer (6) units)

Biostatistics or Statistics with Computers	3 units
St. Thomas on Critical Thinking	3 units

SECOND YEAR

First Semester (9 units)

Physics of Radiation Therapy	3 units
Non-Ionizing Radiation Protection	2 units
Practicum in Radiation Therapy	1 unit
Research Methodology with Instrumentation	3 units

Second Semester (6 units)

COMPREHENSIVE EXAMS

Thesis Writing I (Research Proposal)	3 units
Thesis Writing II (Oral Defense)	3 units

TOTAL No. of Units: 45

The curriculum for the Master in Medical Physics course is the same as the MSc Applied Physics, major in Medical Physics, curriculum except for the following changes: the subjects Thesis Writing I (3 units) and Thesis Writing II (3 units) have been replaced by the subjects Special Topics (3 units), Imaging in Medicine (3 units), and Graduate Seminar (3 units).

The term “units” for all subjects means lecture hours per week; “units” for the Practicum means one month (160 hours) of laboratory and on-the-job practical training; while “units” for Thesis Writing I and II refers to the academic “weight” of the requirement and not to any quantity of time.

The Practicum involves doing a set of laboratory exercises which vary from various quality control/assurance tests of different imaging and therapy equipment to computerized treatment planning and verification for specific cases.

The Students and Graduates

The students admitted to the program have a Bachelor of Science degree in Physics, Applied Physics, Physics for Teachers, Engineering, or Chemistry.

The program has produced a total of twenty one MSc in Applied Physics (Medical Physics) graduates and three Master in Medical Physics graduates. Six of the M. Sc. and all three MMP graduates were produced within the past five years.

Most of the graduates and graduate students working in the Philippines are employed either in the two national regulatory bodies for radiation or in radiation oncology facilities in the country. Seven graduates are working abroad, six as medical physicists.

Innovations

1. Very close coordination with the two radiation regulatory bodies. These are the Philippine Nuclear Research Institute (PNRI) of the Department of Science and Technology (DOST) which regulates

radioactive materials and the Bureau of Health Devices and Technology (BHDT) of the Department of Health (DOH) which regulates radiation devices. As a result, a licensing requirement of both PNRI and BHDT for a radiation therapy facility is the employment of a medical physicist. A BHDT regulation is currently being planned for employment of medical physicists even on a part-time or consultancy basis in x ray facilities doing interventional procedures and mammography procedures.

2. Signing of a Memorandum of Agreement in support of the Medical Physics Graduate Program. Since 1981, two such (MOAs) have been signed by the DOH, DOST and the PNRI. This has assured the availability of equipment and hospital facilities for the students' practicum.

3. Availability of scholarship grants from the Department of Health for their employees

4. Creation of the Medical Physics Advisory Committee of the UST Graduate School composed of the president of the Philippine Organization of Medical Physicists, the president of the Philippine College of Radiology, the president of the Philippine Radiation Oncology Society, the directors of the PNRI and the BHDT, and some faculty members of the program.

5. Creation of a second master course, the Master in Medical Physics course, in addition to the Master of Science in Applied Physics, major in Medical Physics course.

6. Use of electronic training materials such as the EMERALD e-Workbook and Image Database produced by the EMERALD Consortium with Dr. Slavik Tabakov as project leader, and those produced by the International Atomic Energy Agency, with Dr. Madan Rehani as project leader.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Republic of the Philippines

Population estimate, 2009	91,983,000
GDP per capita, 2008	US$1,845
Medical Physicists in Society, 2009	82

Medical Physics Education and Training in Thailand

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Introduction

The education and training of Medical Physicists was started in 1970s in Bangkok, Thailand. The course focused on physics in radiation therapy and nuclear medicine. As the diagnostic radiology is well developed (especially the radiological facilities with digital imaging), the lack of well educated users are the major problem for several universities and private hospitals. Therefore, the expansion of education programs in medical physics had been considered and proposed at Chulalongkorn University for the graduated program in medical imaging.

Motivation

As the medical physics course in Thailand did not cover the physics of medical imaging, Chulalongkorn University approved the first Master of Science Program in Medical Imaging in the year 2002 in Thailand. The program serves the needs in advanced technology and available facilities such as MDCT, PET-CT, MRI, etc in medical imaging in Thailand. Currently, the medical imaging course has been added in other 3 medical physics programs in Thailand.

Objectives

The program encourages the scientists to broaden their knowledge and skill in the field of the science of medical imaging. The students with physical or hospital background will learn more in patient dosimetry and image quality to find employment in hospitals, research institutes, or university. Students will gain knowledge in the areas of obtaining advanced image for the purpose of the proper treatment of the disease.

Duration of the Program

The program is a two year course, started in June and ended by March. The study is divided into 2 semesters per year which the first semester period is June to September and the second is November to February.

Collaborating Institute:
Faculty of Engineering, Chulalongkorn University.
King Chulalongkorn Memorial Hospital, Thai Red Cross Society
Mahidol University

Facilities
Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Thai Red Cross Society, support each other for teaching, research and clinical service. Major clinical equipments are purchased by the hospital budget or from the fund raising, while the teaching and research facilities are supplied by the university. The university and the hospital are almost 100 years old, under the patronage of the Royal Family.

Current Status of the Department
The Department of Radiology includes 25 radiologists and 10 qualified physicists. Thisstaff is overloaded by covering clinical service, research and teaching. Further from medical physic education program, there are other several programs such as the program for medical doctors, technologists, residency training program in radiology and special program for fellows. Therefore the Medical Imaging program could accept only 6 students per year. The first group of graduation was in the year 2004. Up to the academic year 2010, the number of Medical Imaging graduations is 28.

Course Description:
1. **Core Course Subjects:**
    1. Radiological Physics
    2. Radiation Safety
    3. Health Physics
    4. Biomedical Instrumentation
    5. Medical Imaging Anatomy
    6. Diagnostic Imaging

7. Introduction to Image Processing
8. Image Fusion and Picture Archive Computer System (PACS)
9. Medical Imaging Seminars
10. Research
11. Clinical Practicum
12. Thesis

2. **Elective Courses**

A. Diagnostic Radiology
1. Physics of Diagnostic Radiological Imaging
2. Non-Ionizing Radiation
3. Physics of MRI
4. Applications of Image Processing Technique

B. Radiation Therapy
1. Radiation Biology
2. Physics of Radiation Therapy
3. Radiation Oncology
4. Application of Image Processing Technique

C. Nuclear Medicine
1. Application of Image Processing Technique
2. Physics of Nuclear Medicine
3. Biochemistry for Nuclear Medicine
4. Physiology for Nuclear Medicine
5. Clinical Nuclear Medicine Imaging

Course Structure:

Year I:

First Semester	**12 credits**
1. Radiological Physics	2 credits
2. Radiation Safety	1 credit
3. Health Physics	1 credit
4. Biomedical Instrumentation	1 credit
5. Medical Imaging Anatomy	1 credit
6. Diagnostic Imaging	2 credits
7. Introduction to Image Processing	1 credit
8. Image Fusion and PACS	1 credit
9. Medical Imaging Seminars	1 credit
Second Semester	**11 credits**

1. Research	2 credits
2. Seminars in Medical Imaging	1 credits
3. Clinical Practicum	3 credits
4. Thesis	4 credits
Year II:	
First Semester	**10 credits**
1. Selected Courses	7 credits
2. Thesis	3 credits
Second Semester	**5 credits**
Thesis	5 credits
Total	**38 credits**

Inputs needed

Books, equipments, qualified staff are still in need. Such the items should be obtained in the next couple years in order to run the program effectively.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Kingdom of Thailand

Population estimate, 2009	65,905,410
GDP per capita, 2008	US$7,900
Medical Physicists in Society, 2010	250 (40 in 2005)

Master of Science Program in Medical Physics Department of Radiology Ramathibodi Hospital, Mahidol University, Thailand

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Introduction

The Master of Science Program in Medical Physics offered at Ramathibodi Hospital has been established since 1972 with the aid of World Health Organization in curriculum development for educating and training young scientists to be physicists working in fields of Nuclear Medicine and Radiotherapy . Untill now, the program has educated more than 90 Medical Physicists to serve universities and hospitals throughout the country.

The rapid advancement in Radiation Medicine, led to incorporation of highly sophisticate instrumentations in the national healthcare system. Spiral CT, MRI, SPECT or even PET are available in university hospitals including some private hospitals. Functional and anatomical image fusion receives recent attention as an approach for more effective disease mapping or accurate treatment planning. In radiotherapy, many centers offer targeted treatment such as radiosurgery, stereotactic radiotherapy, intensity modulated radiotherapy, etc.

Evidently, the demand of medical physicists for hospital works is continuingly rising. The current program has been revised since the year 2000 in order to prepare our graduates to be able to work in areas of Diagnostic Radiology, Nuclear Medicine and Radiation Oncology.

Objective

To educate and train scientists to be hospital physicists to serve areas of Diagnostic Radiology, Nuclear Medicine and Radiation Oncology.
Duration of the Program - 3 years; Admission - Every other year; Number of Admission: 10-15

Duration of the Program: Three years

Admission: Every other year

Number of Admission: Ten to fifteen

Collaborating Institutes:

1. Faculty of Science, Mahidol University.
2. Department of Radiological Technology,Faculty of Medical Technology, Mahidol University.
3. Department of Radiology, Siriraj Hospital.
4. Faculties of Science and Engineering, Chulalongkorn University.
5. King Chulalongkorn Memorial Hospital.
6. The Division of Radiation and Medical Instrumentation, The Ministry of Public Health .
7. Office of Atoms for Peace.
8. Chulabhorn Cancer Centre

Facilities:

Our program provides learning and training for 3 different fields: Diagnostic Radiology, Nuclear Medicine and Radiation Oncology. Students receive training from standard to advanced machines, such as MRI 3 Tesla, 320 slices volume CT, SPECT and PET-CT machines, CyberKnife with SRS and SBRT techniques, Linear accelerator with a various types of dosimetry and treatment planning systems.

Course Syllabus: Academic Year 2000-

A. Core Courses

1. Radiation Dosimetry
2. Radiation and Nuclear Physics
3. Electronics and Nuclear Instrumentation
4. Physics of Diagnostic Imaging
5. Clinical Dosimetry
6. Nuclear Medicine
7. Radiation Protection
8. Application of Radiation Physics in Radiotherapy
9. Seminar

10. Research M.Sc. Thesis

B. Elective Courses

1. Biology for Medical Physicist I
   Part A Anatomy and Physiology
   Part B Cell Biology
2. Biology for Medical Physicist II
   Part C Pathology and Pharmacology
   Part D Radiobiology
3. Biostatistics
4. Emission Computed Tomography in Nuclear Medicine
5. Advanced Techniques in Magnetic Resonance Imaging and Computed Tomography

Course Structure:

Year	Semester 1	Semester 2
1	RARD 508 Radiation Dosimetry 3(2 – 3) RARD 511 Radiation and Nuclear Physics 3(3 – 0) RARD 512 Electronics and Nuclear Instrumentation 4(3 – 3) *RARD 587 Seminar 1(1 – 0) Elective courses 2 credits **Total 13 credits**	RARD 513 Physics of Diagnostic Imaging 3(2 – 3) RARD 517 Clinical Dosimetry 2(1 – 3) *RARD 587 Seminar 1(1 – 0) Elective courses 5 credits **Total 11 credits**
2	RARD 514 Nuclear Medicine 3(2 – 3) RARD 515 Radiation Protection 3(2 – 3) RARD 620 Application of Radiation Physics in Radiotherapy 2(1 – 3) *RARD 587 Seminar 1(1 – 0) Elective courses 2 credits **Total 11 credits**	RARD 698 Thesis 12(0 – 48) **Total 12 credits**

***Remark:** RARD 587 Seminar: The student is required to give one seminar /semester. A total of three seminars are required. The course will be graded at the end of the first semester in the second year.

Course Description:

Required courses:		24 credits
Elective courses:	minimum	7 credits
Thesis:		12 credits
Total :	**minimum**	**43 credits**

Master of Science Program in Medical Physics at ChiangMai University, Thailand - Faculty of Medicine, Department of Radiology

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Introduction

ChiangMai is the second largest province located in the North of Thailand. The Faculty of Medicine, ChiangMai University, is the first regional medical school outside Bangkok. It was founded in 1959. Today it has about 400 teaching staff and 5,000 personnel. Its affiliated hospital has 1,800 beds. The Master of Science Program in Medical Physics was opened here in 2001which is the second program in Thailand. The Department of Radiology is responsible for this program. The three tracks of radiation therapy, nuclear medicine, and diagnostic radiology are offered.

Motivation

With the rapid translation of new technology into medical instrumentation, physicists are becoming essential in many clinical areas especially in the field of radiology to assure excellent patient care with advanced diagnostic and therapeutic equipments. Realizing the shortage of medical physicist in Thailand, the current program was established at ChiangMai University to provide academic training for this profession.

Objectives

The program aims to produce the qualified medical physicists to serve both public and private radiological centers nationwide. The graduates will gain knowledge of Medical Physics in Radiotherapy, Nuclear Medicine and Diagnostic Radiology with specializing in one of these topic areas and be able to work in either clinical or research situation.

Duration of the Program

The program duration is 2 academic years full time and must not exceed 5 academic years, which is to comply with the Regulations of ChiangMai University on Graduate Degree Program.

Collaborating Institute:

Physics Department, Faculty of Science.

Facilities:

The Department of Radiology is well equipped with advanced diagnostic and therapeutic machines that available for the students to practice and perform their research works.

Current Status of the Program:

Currently the program has twenty six staff members including the MD who are responsible for the clinical courses. Since the beginning, twenty four students were accepted in the program and six of them were graduated. All of them are now working in the government sections. Eight students are expected to graduate this academic year.

Course Description:

Course work:	minimum	27 credits
Thesis:		12 credits
Total :	minimum	39 credits

1 Field of concentration courses minimum of 21 credit

1.1 Required courses	**13 credits**
- Radiation physics	3
- Radiation biology	3
- Electronics for Medical physics	3
- Advanced radiation protection	2
- Seminar in Medical Physics I	1
- Seminar in Medical Physics II	1
1.2 Elective courses (concentration) 8 credits	
<u>Radiation Therapy Track</u>	
- Radiation Therapy Physics	2
- Fundamental of Dosimetry	2

- Radiation Therapy Instruments and Methods 2
- Practice in Radiation therapy 2

Nuclear Medicine Track
- Fundamental and Radiation Protection of Nuclear Medicine 2
- Nuclear Medicine Instruments and Quality Assurance 2
- In vitro Nuclear Medicine 2
- Clinical Nuclear Medicine 2

Diagnostic Radiology Track
- Physics of Diagnostic Radiology 2
- Physics of Medical Imaging 2
- Instruments and Quality Assurance in Diagnostic Radiology 2
- Practice in Diagnostic Radiology 2

2 Other courses minimum of 6 credit

2.1 Required courses (other) 3 credits
- Nuclear Instruments and methods 3

2.2 Elective courses minimum of 3credits
- Electromagnetism for applied physics 3
- Principle of Human Anatomy 4

3. Non credit course
- Nuclear Physics I 3
- Nuclear Physics II 3
- Biochemistry for Radiologic Technology Students 3

- Physiology for Medical Technology and Radiological Technology Students 4

4. Thesis 12 credits

Study Plan

First year	
Semester 1	*Semester 2*
Radiation Physics	Radiation Biology
Advanced Radiation Protection	Nuclear Instruments and Methods
Electronics for Medical Physics	Principle of Human Anatomy** (Electromagnetism for Applied Physics)*
Biochemistry for Radiologic Technology	Physiology for Medical Technology and Radiologic

Students** (Nuclear Physics I)*	Technology Students** (Nuclear Physics II)*
Second Year	
Seminar in Medical Physics I	Seminar in Medical Physics II
Elective in Field of Concentration Courses	Thesis
*elective courses for graduate students in Health Sciences ** elective courses for graduate students in Physics	

Medical Physics Education in Bangladesh

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Introduction

During 1996, 1997, 1998, 1999 the task group of the German Society for Medical Physics (DGMP) "*DGMP Medical physics in developing countries*" with the physics department of the *Bangladesh University of Engineering and Technology (BUET)* arranged a one week medical physics seminars/workshops in Dhaka. The seminars were largely attended by physicists working in nuclear physics, solid state physics, radiation protection, nuclear medicine and by physicians from radio-oncology and nuclear medicine. As a result of these seminars the *Bangladesh Medical Physics association (BMPA)* has been founded in July 1998. After registration in 2009, it is called *Bangladesh Medical Physics Society (BMPS).*

The first impetus to start a *Department of Medical Physics and Biomedical Engineering* in Bangladesh came from that time. Dr. Golam Abu Zakaria, Professor of medical physics and the initiator of the seminars, was trying to open a department in the public universities like *BUET*. But at that time this subject was new in Bangladesh and it was not possible to open such a department in public universities for different reasons. In 2001, a private University, *Gono Bishwabidyalay (University*) came forward to accept his proposal of starting a master program both in medical physics and in biomedical engineering. The department was the result of many discussions with the experts of many public and private universities and authorities of *University Grant Commission*. This was the first attempt to establish full fledged

Master courses in Medical Physics and in Biomedical Engineering of international standard in Bangladesh. The University Grant Commission of Bangladesh officially recognized this course (with 2 years duration). It is worth mentioning that the physics department of *BUET* introduced some courses on medical physics at the post-graduate level for first time in Bangladesh as early as 1994.

Another Master program on Medical Physics was also started locally in another private University named *South East University* in 2004. From that university three students have got MSc degree in Medical Physics. However they could not continue their program due to the shortage of teachers specialized on medical physics and proper equipment. In general it is very hard to get students in private universities due to high fees for study. The Government is on the way to adapt a policy for appointment of medical physicist in radiotherapy departments of the public Medical Colleges. A number of cancer hospitals have been started by private enterprise but there is still a great shortage of medical physicists both in radiotherapy and diagnostic imaging.

In a situation like this, we in the *Gono Bishwabidyalay* are trying hard to create specialists on medical physicists and biomedical engineers with local and international cooperation, especially in the field of cancer treatment and research. In this report we try to describe the present situation of medical physics education in Bangladesh especially the program of medical physics in *Gono Bishwabidyalay (University*).

Entrance Requirements and the Course in Gono University

First Stage :

The basic eligibility for admission is a master's or a graduate degree in physics or related field in physical sciences, biosciences, medicine, or engineering disciplines. Every student must have at least a second class in degree examination.

Second stage:

We have developed our syllabus based on *DGMP* document for the postgraduate course in medical physics, but according to the need of

Bangladesh. The course structure is designed to prepare the students for the work in hospitals, health institutes and for research in medical physics. The curriculum of the M.Sc course in medical physics at *Gono Bishwabidyalay* is given in the appendix. The duration of the course is 4 semesters i.e. 2 years. The syllabus is taught in the form of lectures as well as practical works. The total course covers 54 credits for lectures and 36 credits for practicals over the first three semesters and a thesis (30 credits) is completed in the 4th semester. Formal examination is held after each semester and these are monitored by the MSc course committee and external examiner (from Germany and local institutions). Practical classes are carried out in the departmental laboratory and also in the radiotherapy and radio diagnostic departments of the different hospitals.

Later in 2003, a collaboration program has been materialized between *Heidelberg University*, Germany and *Gono University*, Bangladesh. The education and training have been the primary objective of this collaboration. Under this collaboration there has been exchange of teachers and students between *Gono University* and *Heidelberg University* with the financial support of *DAAD (German Academic Exchange Program)*. Our department is also receiving equipment, educational materials such as books, reports mostly offered by the Human Health Division of *IAEA*, journals and research materials from Germany. A modern dosimetry system (calibrated Farmer type chamber, plane-parallel chamber, electrometer, slabs phantom, 2D water phantom, densitometer, sensitometer) and a treatment planning System (TPS) are also provided from Germany.

Professors from Germany visit *Gono Bishwabidyalay* twice a year and deliver lectures, give guidance to the students and teachers. They also help in the preparation of the thesis proposal and assessing the thesis work.

Students have to complete a dissertation on a specific research topic on medical physics in the last semester. The practical part of the thesis is done in *German Cancer Research Center (DKFZ)* in collaboration of the *Heidelberg University*, Germany for 3 months under the agreement of *DAAD* funding. The remaining part of the thesis is completed in Bangladesh. Theses are supervised by the local professor and also professor of the medical physics from Germany. After proper evaluation of the thesis, the oral examination is held by an examination board consisting of supervisors, internal examiners as well as the external examiners from local or from German Universities, an MSc degree is awarded in medical physics.

Some students are expected to reach a higher academic level by preparing and defending a PhD thesis in medical physics. Currently two teachers are doing Ph.D on medical physics. Their practical parts are also held in *Heidelberg University*.

Third Stage

This step is training in hospitals. The training program is aimed at providing hospital based medical physics training. At present modern radiotherapy machines (specially linear accelerators) are installed in different governmental and private hospitals in Bangladesh. Those modern hospitals will be the source for practical training as well the work place for medical physicists. However, small number of medical physicists, graduated *Gono Bishwabidyalay,* have the opportunity of training abroad through different development projects. In spite of the absence of Government policy for appointment of medical physicist in radiotherapy department, those hospitals or Institutes are trying to recruit medical physicist personally and sending them abroad (India, Germany etc) under special project for higher training and experience to work on the machine which will be installed in that specific hospital.

Present Status of Medical Physicists in Bangladesh

Medical physicists in Bangladesh are working mainly in the nuclear medicine departments associated with University hospitals. The 15 *Nuclear Medicine Centers* of the country are under the direct control of *Bangladesh Atomic Energy Commission (BAEC).* From the very inception of these centers, *BAEC*, with the help of *IAEA* fellowships, has developed a good pool of trained manpower in this field. But the situation of medical physics manpower in radiotherapy is completely different. In Bangladesh the medical physics in radiotherapy and x-ray diagnosis is poorly developed.

A few numbers of medical physicists have been working in the radiotherapy of a private hospital named *Delta Medical Center*, in Dhaka. They have obtained their professional skill and knowledge while on job and through the training in summer schools, workshop of different medical physics organizations. All other radiotherapy departments in other hospitals (13 in total) are working without medical physicists.

Until 2010, after opening of the *Department of Medical Physics and Biomedical Engineering* in *Gono University,* twelve students have received MSc degree in medical physics. We would like to develop a strong and advanced medical physics program for education and research in our department and in the country at large by incorporating the latest developments in imaging and radiotherapy. We expect to establish further close collaborations with other teaching and research institutes and to increase our participation in international scientific events. At present master degree owned students are working in the radiotherapy department of *National Institute of Cancer and Research Hospital (NICRH*), radiotherapy department of *Dhaka Medical College*), radiotherapy departments of different Private hospitals (United Hospital, Square Hospital, Khaja Younus Medical College Hospital), and in the teaching of medical physics in *Gono University*. Now 3 students are working on their master thesis in medical physics of radiotherapy. The number of medical physicists working in radiotherapy and imaging is shown in the following table 1.

Table1: Number of medical physicists in different disciplines

Discipline	till 2003	since 2010
Nuclear medicine	50 (approx.)	50
Diagnostic imaging	No	6
Radiotherapy	3	20

In 2006 our department has also opened BSc in Medical Physics and Biomedical Engineering. Now there are 50 students in this BSc course. They are working on projects on different topics on diagnostic imaging and radiotherapy. This course is for 4 years and 8 students have already received BSc degress. This course will be also collaborated with the German University for medical physics and biomedical engineering (currently in process).

Future Need

By the year 2015 it is expected that the number of new cancer cases being detected per year world-wide will increase to about 15 million cases, of which two thirds will occur in developing countries. In these countries, the typical incidence of new cancer patients is 75 – 150 per 100000 population. According to *WHO,* country like Bangladesh with such number of cancer cases need 2 megavoltage teletherapy machines per 1 million people. For 130 millions Bangladeshi we need at least 260 megavoltage teletherapy machines (in another prediction – 320). Bangladesh needs 160 radiotherapy facilities to cover an optimal standard of radiotherapy treatment. This means that minimum 500 qualified medical physicists are required in future to satisfy the demand in radiotherapy and more if we are considering the need in diagnostic radiology departments

At present only 20 medical physicists are employed in different radiotherapy departments. The *Bangladesh Radiation Oncology Society* has submitted a proposal to the Government for the creation of 62 positions for physicists in the present 14 radiotherapy departments of medical colleges in the country. It is very promising that in the proposed positions the medical physicists have been projected as equal partners to the radiation oncologists in the treatment of cancer. The Government has already created the proposed 62 positions (the implementation is delayed due to some bureaucratic reasons). We hope that the number of medical physicists will increase in the near future and also the professional level of competence will increase rapidly after 2-3 years.

The experiment to establish a *Department of Medical Physics and Biomedical Engineering* in *Gono University* is an encouraging step. Other Universities of the country should follow this example to build up the necessary manpower in medical physics to meet the country's need. The number of private hospitals for treatment of cancer patient is increasing. This is a good news for our profession. Both internal effort and external support are very important for further development of medical physics education and as well as for professional skill.

Future Aims for Improvement of Medical Physics in Bangladesh

In Department Level

- Focusing the education to:
  - Self-sufficiency in teaching on medical physics (theoretical, practical and thesis)
  - Clinical training in medical physics in Bangladesh hospitals and hospitals of other countries like Germany, India, USA etc.
- Use of the various existing teaching material, for instance offered by the *Human Health Division* of the *IAEA*
- Development of teaching program in electronic media
- Participation and involvement in new radiotherapy center projects in Bangladesh
- Integration of the bilateral *Heidelberg-Dhaka* project into international programs such as *PACT*
- To publish popular articles in Bengali or in English language to create public awareness regarding role of medical physicists in cancer diagnosis and treatment and its recent development.

In BMPA Level

- Development of common curricula for medical physics education and training in Bangladesh.
- Development of recognition procedure for qualified medical physicist
- Demand for the creation of at least two posts of physicists at each department of radiotherapy or of medical physics dept in hospitals.

- A close collaboration with national and international health care associations like the *German Society for Medical Physics*, the *Bangladesh Society of Radiation Oncologists*, the *Association of Medical Physicists of India, Abdus Salam International Center for Theoretical Physics* etc.
- Organizing annual conference on medical physics.
- Publication of a Half-yearly medical physics journal in English.

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Appendix

Curriculum of the MSc course in Medical Physics at Gono Bishwabidyalay (University)

Remark: The Credit System used here is according to the European Credit Transfer and Accumulation System (ECTS). It follows that 1 Credit is about 1.5 h Student Workload per week (with 18 weeks per semester).

1st Semester (30 Credits)

Course Number	Course Title	Lectures (h/week)	Credits
1101	Radiological Physics and Dosimetry	3	3
1101 L	Radiological Physics and Dosimetry Lab	2	2
1102	Anatomy, Physiology	2+2	4
1102	Anatomy& Physiology Lab	1+1	2
1103	Biostatistics	2	2
1103 L/ V	Biostatistics Lab	2	2
1104	Mathematics and Computational Skills	2+2	4
1104 L	Mathematics and Computational Skills Lab	1+1	2
1105	Professional Ethics	1	1
1106	Radiation Biology	3	3
1106 L	Radiation Biology Lab	1	1
1107	Biomedical Electronics	2	2
1107 L	Biomedical Electronics Lab	1	1
1108	Semester Viva	-	1
	Total	29	30

2nd Semester (30 Credits)

Course Number	Course Title	Lectures (h/week)	Credits
1201	Conventional Planar Imaging	2	2
1201 L	Conventional Planar Imaging Lab	2	2
1202	Digital X-Ray Imaging and Computer Tomography	2	2
1202 L	Digital X-Ray Imaging and Computer Tomography Lab	2	2
1203	Ultrasound Imaging	2	2
1203 L	Ultrasound Imaging Lab	2	2
1204	Brachytherapy	4	4
1204 L	Brachytherapy Lab	3	3
1205	External Beam Radiation Therapy	3	3
1205 L	External Beam Radiation Therapy Lab	2	2
1206	Radiation Therapy Devices	3	3
1206 L	Radiation Therapy Devices Lab	2	2
1207	Semester Viva	-	1
	Total	29	30

3rd Semester (30 Credits)

Course Number	Course Title	Lectures (h/week)	Credits
1301	Magnetic Resonance Imaging	3	3
1301 L	Magnetic Resonance Imaging Lab	2	2
1302	Nuclear Medicine	3	3
1302 L	Nuclear Medicine Lab	2	2
1303	Radiation Oncology	3	3
1303 L	Radiation Oncology Lab	2	2
1304	Treatment Planning	3	3
1304 L	Treatment Planning Lab	3	3
1305	Special Techniques in Radiotherapy	3	3

1305 L	Special Techniques in Radiotherapy Lab	2	2
1306	Radiation Protection	2	2
1306 L	Radiation Protection Lab	1	1
1307	Semester Viva	_	1
	Total	29	30

4th Semester (30 Credits)

(Course Name: Master Thesis)

Course Number	Preparation(Applicants has to be present at least one seminar before thesis submission)	Thesis	Examination
MP 1400	5	20	5

*Students have to pass each individual part of this course

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

People's Republic of Bangladesh

Population estimate, 2009	162,221,000
GDP per capita, 2009	US$520
Medical Physicists in Society, 2009	50

BIOMEDEA - Biomedical Engineering in the European Higher Education Area

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INTRODUCTION

Medical and biological engineering and sciences (MBES) are advancing at a breathtaking pace and through this evolution of MBES, medicine and health care have developed into a highly specialized technological branch where biomedical engineering plays an essential role, not only in providing a safe health care environment. Within this field, Biomedical Engineering is not just a multidisciplinary approach to combined biomedical and engineering problems, but a new discipline with its own way of thinking. MBES has become a major source of industrial diversification with a huge potential for being a catalyst, enhancing the generation of new industries and creating many new start-up companies. These developments coincide with the political efforts to establish the Europe of Knowledge as a most competitive economic region, to be realized by the creation of the European Research Area and through the Bologna Process, which is aiming at setting up a European Higher Education Area (EHEA) through the Europe-wide harmonization and quality control of higher education.

As a unique opportunity to promote MBES, the Bologna movement has triggered an initiative of the European MBES community to establish their Higher Education Area by harmonizing the educational programs, specifying minimum qualifications and developing criteria for an efficient quality control of education, training, life-long learning and certification. For this purpose, in 2004 the BIOMEDEA project [1] was established, with the objective to develop, implement and sustain consensus on criteria, guidelines and protocols for the harmonization and accreditation of high quality Medical and Biological Engineering and Science programs, and for the training, certification and continuing education of professionals working in the health care systems with the goal to insure mobility in education and employment as well as the highest standards for patient safety in the health care systems. BIOMEDEA is a mainly European project in which currently more than 80 universities and other academic institutions participate. The initiative, with the Institute of Biomedical Engineering at the University of Stuttgart as the lead institution, is supported by the International Federation for Medical and Biological Engineering (IFMBE). It closely cooperates with the European Virtual Campus for Biomedical Engineering (EVICAB) and the World Health Organization (WHO).

ORGANIZATION

In 2004, BIOMEDEA was launched as a European participation project, a loose cooperation of individual faculty members representing European universities and biomedical as well as clinical engineering societies, aiming at contributing to the realization of the European Higher Education Area in MBES for the benefit of the universities, the students, the health care systems and last but not least the European people.

The work within the project, achieving consensus and devising documents on Biomedical and Clinical Engineering Education, Accreditation of Programs, Training and Certification of Individuals is done mainly through workshops bringing together all the stakeholders. So far, the initiative attracted representation of more than 80 European, a number of North and South American and Asian universities as well as numerous national and international BME societies and other interested organizations including the World Health Organization (WHO) and lead to a close interaction with the International Labour Organization (ILO) which is responsible for the classification of all professions, including biomedical engineers. The participating universities have been encouraged to submit regularly updated detailed information on their BME programs, which are assembled by BIOMEDEA as a European study guide to facilitate and support student and teacher mobility. Additionally, all European biomedical engineering societies submitted and regularly update reports on the status of BME, specifically BME education and regulation, in their countries.

The development of Biomedical Engineering over the past 50 years has been an incredible success story, widening the scope of this new scientific, engineering and health care discipline to such an extent that no European university has the resources to represent the full range of research fields and education. Ideally, however, each student in every European university should be able to select any of the areas of BME as his or her specialty. Thus, student mobility between universities and mutual recognition of acquired competences have become very important and are two main objectives of BIOMEDEA. The goal of free choice of courses throughout the numerous specialties within BME can be achieved not only through student mobility, but also through a Europe-wide or even worldwide offering of e-learning courses. For this purpose, BIOMEDEA has established a partnership with the European Virtual Campus for Biomedical Engineering (EVICAB, www.evicab.eu). EVICAB is a platform which provides a high-quality educational program on Biomedical Engineering for students in the European Union and worldwide. EVICAB includes Lecturing Courses taught by the best international scientific and pedagogical experts in this field. The courses are available in various modalities, provided with additional pedagogical material, and they are recognized by many European universities. Participation in EVICAB is available free of charge.

AIMS AND OBJECTIVES

The objective of BIOMEDEA is to prepare and, as far as it will be possible through the means of the involved partners, establish the European Higher Education Area with improved quality assurance, i.e. accreditation of the educational programs and certification of clinical engineers, thus ensuring trans-national mobility for education, training and employment. Quality assurance of MBES education and training is also directly related to the issues of health care quality. It offers the additional advantages of providing certainty for the employer that the employee has the necessary education, training and responsible experience, and confidence for the user, meaning the patient, that those render the service are effective and competent.

The proposed project aims at establishing Europe-wide consensus on guidelines for the harmonization of high quality MBES programs, their accreditation and for the certification or even registration and continuing education of professionals working in the health care systems through the organization of workshops where such guidelines are developed and approved after careful preparation by a core group of experts relying on the input of all relevant partners and stakeholders. Adherence to these guidelines will insure mobility in education and employment, improved competitiveness of the European biomedical industries, as well as the necessary safety for patients, and thus contribute to the health and well-being of the European people. Targets for the dissemination of results are the European universities, students, accreditation agencies, including the US Accreditation Board for Engineering and Technology (ABET), European educational organizations such as the European Association for Quality Assurance in Higher Education ENQA [2], European University Association EUA, European Association of Institutions in Higher Education EURASHE, European Students' Union ESU and European Standing Observatory for the Engineering Profession and Education ESOEPE, scientific and professional organizations like IFMBE, the health technology industry, political decision makers, the health care systems, and international organizations such as WHO and ILO.

In parallel to the harmonization of education, new international programs will evolve. These and all other MBES programs will be accessible for students and teachers on the EAMBES web site, facilitating mobility and the planning of individual curricula encompassing different European universities.

The project ties together all the needs and requirements of a young and rapidly growing academic discipline and nearly all European academic institutions and professional societies with an interest in MBES to prepare for the European Higher Education Area, realizing in the process major benefits for the "Europe of Knowledge", i.e. improved competitiveness of the European economy, and the health and well-being of the European people. The new approach of bringing together all parts of the multi-clustered, multi-disciplinary MBES community, academia, scientific and professional societies, industry and individual experts, to find consensus on the relevant issues and speak with one voice, enables this ambitious, innovative project to become reality.

OUTCOMES

The main outcomes of BIOMEDEA so far have been recommendations and guidelines for the competencies to be acquired by students in Bachelor and Master programs, criteria for the accreditation of biomedical engineering programs, protocols for the formation, training, certification and continuing education of clinical engineers, and for an internationally recognized clinical engineering certification system and register. Also, status reports on biomedical engineering education in most European countries have been published. A study guide, detailing all national and international MBES programs in Europe will complement the status reports.

The recommendations and guidelines are based upon European agreement on:

- an Undergraduate Biomedical Engineering Curriculum, delineating the core topics in biomedical engineering science that all BME students should understand, the biomedical engineering science topics, fundamental areas of BME specialization, and the critical skills expected of all undergraduate biomedical engineers;
- a Biomedical Engineering Master Curriculum outlining at the graduate level intellectual underpinnings for the future of biomedical engineering, integration of the engineering sciences and modern biology, engineering opportunities in the hospital, and critical skills;
- basic competencies in engineering/science, biology and medicine as well as general qualifications including “soft skills” as minimum output requirements for accredited BME programs;
- BME core competencies and specializations that should be recommended in the guidelines for the accreditation of BME programs in Europe;

- guidelines specifying a flexible framework of BME curricula as a guide for the accreditation of BME programs;
- a training scheme, establishing a European Protocol for the formation and training, certification and continuing education of biomedical or clinical engineers working in a hospital environment.

The main documents are:

- Criteria for the Accreditation of Biomedical Engineering Programs in Europe [3]
- Protocol for the Training of Clinical Engineers in Europe [4]
- Protocol for Continuing Education of Biomedical/Clinical Engineers in Europe [5]
- Protocol for an Internationally Recognized CE Certification System and Register [6]
- Biomedical Engineering Education in Europe - status reports [7].

The recommendations and guidelines have found acceptance throughout Europe. Many new programs adhering to the recommendations have been established and the transition from old national degree programs, such as Diploma programs, to the Bachelor/Master system in the wake of the Bologna movement has been arranged in accordance with the BIOMEDEA guidelines. Adherence to these guidelines insures mobility in education and employment. Realizing the EHEA for MBES in cooperation with all relevant groups will also further the professional standing of MBES and the competitiveness of European education, industry and the health care systems. A survey of the current status of the EHEA for MBES [8] demonstrates that its implementation is steadily progressing and that its impact will be beneficial for the quality of education and training.

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The Tuning Process and the Masters in Medical Physics in Europe - a Personal Vision

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Introduction

The Bologna Declaration in Europe (June 1999)[1] launched a process aimed at creating a European Higher Educational Area (EHEA), committing states to reform their higher education systems in a *convergent* way. The Bergen Conference (May 2005) adopted an overarching qualifications framework for higher education in Europe (QF-EHEA), consisting of three cycles (Bachelor, Master, Doctorate) and programme-independent learning outcomes for each cycle.[2] The 'Tuning Educational Structures in Europe' is the universities' contribution to the process. A fundamental objective of Tuning is the convergence of the learning outcomes of *specific programmes* (e.g, Masters in Medical Physics). This is to be achieved principally through the development of inventories of agreed minimum pan-European programme learning outcomes defined in terms of competence statements. Convergence does not imply uniformity as this would stifle diversity and the ability to adapt to local conditions or innovate; variety in curricular delivery and student options is encouraged. The 'Tuning' should be carried out by an alliance of universities, professional associations, employers and recent graduates.[3] Following a proposal by the present author, EFOMP Council (September 2008 Krakow) set in motion the Tuning process for Masters programmes in Medical Physics in Europe. An initial inventory was developed by the same author under the auspices of the EFOMP Education and Training committee and presented by the EFOMP President at WC2009 Munich (in this article referred to as the 'Munich Inventory').[4] This chapter explains the personal vision guiding the development of the inventory and suggestions for further development.

Curriculum development and role development

Curriculum development is inherently both future-oriented and political in nature. It is future-oriented in the sense that it must be designed to ensure the future employability of graduates; it is political because learning outcomes must be based on the desired future role of the profession as defined by its members. The future role should in turn be defined following an objective systematic strategic planning exercise based on matching the internal strengths and weaknesses of the profession to external opportunities for and threats to the profession arising from the external Political, Economic, Social-Psychological and Techno-Scientific environments.[5-7] The central question one should be asking is: What should the future role of the profession be so that it would be relevant in 5-10 years time and its members employable? *The answer to this question would determine curricular content.*

Present role definitions of the medical physics profession in Europe

On a European scale we are presently faced with two unequal definitions. The definition from EFOMP is that medical physics is "the scientific discipline which is concerned with the application of the concepts and methods of physics in medicine".[8] On the other hand, a legal definition of a 'Medical Physics Expert' (MPE) can be found in Directive 97/43/Euratom which defines the MPE as a "an expert in radiation physics or radiation technology applied to exposure, within the scope of this Directive, whose training and competence to act is recognized by the competent authorities; and who, as appropriate, acts or gives advice on patient dosimetry, on the development and use of complex techniques and equipment, on optimization, on quality assurance, including quality control, and on other matters relating to radiation protection, concerning exposure within the scope of this Directive."[9] The EFOMP definition though meaningful to members of the profession is too general to carry weight with legislators, healthcare authorities and the general public and is therefore strategically weak. It does not answer in a succinct manner the following question at the back of every employer's mind: "Why do I need to train, employ and pay medical physicists?" On the other hand the Euratom definition is limited by the reach of a single specific directive and is therefore too narrow in scope to be suitable as a general definition of the role, referring as it does exclusively to medical physicists practicing within the realm of ionizing radiation (what EFOMP calls the 'Specialist Medical Physicist' in Diagnostic/Interventional Radiology, Nuclear Medicine or Radiotherapy)[10]. Limited scopes present a threat to any profession as one would essentially be putting 'all one's eggs in one basket' - in a time of rapidly changing economic, social and healthcare environments this is inherently unwise. *A guiding role definition was required which whilst still encompassing the traditional role of medical physicists within ionizing radiation put the profession on a stronger footing and opened up other avenues for role development.*

Future development of the profession

Unfortunately no formal strategic planning process has yet been carried out by the profession either in Europe or elsewhere, however recent research by an EFOMP Special Interest Group (SIG) led by the present author regarding that component of the role of the medical physicist pertaining to the education and training of the healthcare professions offers guiding directions:[11-13]

a) To ensure that any role within healthcare remains relevant it must be linked to important themes such as quality (i.e., clinically-effective, evidence-based services), safety (patient, occupational, public) and economic issues.[14]

b) To enhance the perception of the role vis-à-vis healthcare authorities/employers and to overcome the ambiguity of the EFOMP definition it is important to redefine the role in terminology associated with European directives. This can be done by redefining the role in terms of medical devices and associated safety issues linked to physical agents, both of which are supported by many EU directives.[9,15-23]

c) In order to offset the limited scope of the MPE role as defined by the Euratom directive it is important to extend it to *all medical devices* (i.e., not only those associated with ionizing radiation) and safety from *all physical agents* associated with devices (i.e., again not only ionizing radiation). In other words *we need to start looking upon ourselves as medical device experts and not only ionizing radiation device experts.* This concept is not entirely new, in fact in several countries we already have medical physics specializing in imaging with non-ionizing radiation (several), clinical physiology and neurophysiology (FI), and audiology (NL).[24]

d) As more healthcare professions move into higher education certain roles traditionally within the remit of the medical physicist (e.g., routine constancy testing using well established non-complex protocols) are being devolved to other professions (mainly for economic reasons as their training is less expensive). However it is still necessary that such activities be managed and overseen by medical physicists as they are very heavily physics and engineering based and only medical physicists have the necessary technological physics competences at sufficiently high level.

The development of the Munich Inventory

In the light of the above analysis the definition of the future role of the medical physicist guiding the development of the Munich Inventory can be expressed in terms of the following mission statement:

"*Medical physicists will contribute to the development of quality, safe and economical healthcare services through the management of medical devices and risks from associated physical agents, including expert consultancy and direct involvement in clinical practice, training and research.*[12,13]

Medical device management involves the management and carrying out of those technological physics activities leading to the quality (clinically-effective, evidence-based), safe, and economical use of medical devices. 'Clinically-effective' means ensuring that the intended clinical purpose for which the device is used is attained. 'Evidence-based' indicates that service development should be based on published results or direct own research in the absence of the former. 'Safe' refers to risks from physical agents associated with medical devices whilst 'physical agents' refers to ionizing radiation, mechanical, electrical, acoustic, ultrasonic, magnetic, electromagnetic, high temperatures, optical, ultraviolet, infrared, and laser sources. 'Economical' refers to the extent to which clinical purpose is achieved at minimum device use time and that the device is used to the utmost of its capabilities. This widening of the role implied that the curriculum needed to be structured in a way that students would have a good grounding in general medical device techno-physics and management of risk from physical agents followed by options which include both the traditional areas of medical physics involvement (i.e., Diagnostic Radiology, Nuclear Medicine and Radiotherapy) and other medical specialities including those based on emerging technologies. Since the widened role is managerial and consultative in nature, competence in medical device procurement, introduction of new technologies within the service, risk management, health technology assessment and human resource development (medical device and safety training of healthcare professionals) become important as do Generic (Tuning terminology for cross-disciplinary) learning outcomes such as leadership, organization and planning, interpersonal skills and innovation take on new significance. The learning outcomes inventory presented at Munich was competence statement based as required by Tuning and was set up on the basis of the above definition, Tuning documentation and medical physics competence statement inventories from various EU states and European organizations such as ESTRO. The competence statements were divided into Generic Competence statements and Subject Specific Competence statements, whilst the Generic Competence statements were in turn further subdivided into Instrumental, Interpersonal and Systemic Competence statements as required by Tuning.[3] The Subject Specific Competence statements were categorized into four sub-categories:

1. Competence statements for the medical physicist as physicist at Masters level
2. Competences statements for the medical physicist as a healthcare professional
3. Competence statements for the medical physicist as medical device / physical agents expert (these were referred to as “core medical physics” in the original inventory and consist of competence statements applicable to all medical devices and safety from associated physical agents).
4. Competences statements for the various specializations of medical physics (i.e., the application of the activities described in competence statements in sub-categories 1-3 above to the devices in the various specializations of medical physics). It was suggested that students

choose optional areas of specialization according to their desired career goals from those offered by the institution. The specializations on offer should include Diagnostic Radiology, Nuclear Medicine and Radiotherapy so that students would have the option of specializing in the traditional ionizing radiation specializations and also other newer specializations such as Clinical Physiology, Audiology, Medical Lasers, Organ/Tissue Replacement in line with the desired widening of the role in the particular country. For example a student aiming to work in Cardiology would have little need for Radiotherapy but would need a very good grounding in those devices/physical agents involved in Diagnostic Radiology, Diagnostic Nuclear Medicine, Clinical Physiology and Organ / Tissue Replacement.

The competence statements within sub-categories 1-3 are presented as an Appendix to give an indication of the state of development of the inventory at the time. The competence statement inventories for the specializations of medical physics are not presented as these were still at a rudimentary stage and will be finalized following the publication of work presently being carried out by specialized groups.

Future development of the Munich Inventory

The Munich Inventory at it stands at present should be looked upon as a work in progress. It is suggested that it should be developed in the following manner:

a) The inventory needs to be expanded and some competence statements reworded

b) The inventory needs to go through a formal validation process involving academics, employers, recent graduates and professional bodies as required by Tuning. The objective would be for stakeholders to reach consensus regarding the importance and desired level of achievement of each competence for students to be well prepared for their future profession.

c) In April 2008 the European Parliament and Council published a European Qualifications Framework for Lifelong Learning (EQF-LLL).[25] The framework categorizes all qualifications (including QF-EHEA qualifications) into 8 levels and is broader than the QF-EHEA as in addition to academic qualifications it also encompasses vocational and professional qualifications at all levels. On this scale Bachelor's programmes are on level 6, Masters level 7 and Doctorates level 8 (whether academic or professional). At each level learning outcomes are defined not only in terms of competence statements as in Tuning but in terms of Knowledge (facts, principles, theories, practices), Skills (cognitive and practical) and Competence (here meaning responsibility and autonomy). It is not yet been made clear how this framework will be reconciled with Tuning, however once this is made apparent the inventory would need to be restructured accordingly.

d) The learning outcomes for the various specializations of medical physics need to be developed. At the moment there are several European groups working to produce learning outcomes for the Qualified Medical Physicist (i.e, Masters in Medical Physics followed by 2 years of supervised training) in Diagnostic Radiology, Nuclear Medicine and Radiotherapy. Once the work of these groups is finished we would need to distinguish between those learning outcomes that should be acquired during the Masters and those to be acquired during the supervised training period. Working groups need also to be set up by EFOMP to produce inventories of learning outcomes for Qualified Medical Physicists in other specializations of medical physics.

Conclusion

This chapter described the process of the development of the Munich Inventory for the Tuning of the Masters in Medical Physics in Europe together with indications of how it could be developed further. Although the inventory is by no means complete and needs to be improved it does provide a robust structure around which a further refined inventory can be built. It also provides an important reference document for curriculum developers in Europe.

Acknowledgements

Although the title of this chapter includes the phrase 'a personal vision', it does not consist of the musings of a single author. The 'personal' vision has been remodified iteratively following many discussions

(both formal and informal over many coffees and beers) over many years with many medical physicists too numerous to mention by name.

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Appendix: Munich Inventory of Learning Outcome Competence Statements for Masters in Medical Physics in Europe

Generic Competence Statements

Instrumental

1. Demonstrate a capacity for analysis and synthesis.
2. Demonstrate ability for organisation, planning and management of one's workload.
3. Demonstrate ability to retrieve and analyse information from different sources.
4. Display effective oral and written communication in the native language.
5. Be able to use general productivity software.
6. Demonstrate problem solving skills.
7. Demonstrate decision taking skills.
8. Demonstrate knowledge of a second language.

Interpersonal

1. Be able to be critical and accept criticism.
2. Demonstrate ability to work in both mono-disciplinary and multi-disciplinary teams.
3. Be able to communicate orally and in writing with both experts in the field and non-experts.
4. Demonstrate respect for diversity and multiculturality.
5. Be able to work in an international context.
6. Demonstrate ethical commitment.

Systemic

1. Demonstrate an ability to apply knowledge in practice
2. Demonstrate a capacity to learn.
3. Be able to apply research skills.
4. Demonstrate a capacity to adapt to new situations.

5. Demonstrate ability to generate new ideas (creativity).
6. Demonstrate leadership and initiative.
7. Be able to work autonomously.
8. Be able to design and manage projects.
9. Demonstrate an ongoing concern for quality.
10. Demonstrate reflection and evaluation of own practice.
11. Take responsibility for one's own learning.
12. Demonstrate an entrepreneur spirit.
13. Demonstrate a will to succeed.

Subject Specific Competence Statements

Physics Competence Statements at Master Level

1. Have advanced knowledge and understanding of theoretical areas of physics relevant to medical physics at level of Masters.
2. Demonstrate skill in physics laboratory techniques and use of equipment at the level of Masters.
3. Use mathematical and modeling techniques appropriate for medical physics at Masters level.
4. Demonstrate research communication skills (poster, article and oral) at the level of Masters.

Competence Statements as a Healthcare Professional

1. Understand the functions of healthcare organizations, the way healthcare is organized and principles of clinical governance.
2. Understand those sections of the human biological sciences (anatomy, physiology, pathology, cellular and biomolecular science, medical imaging) to a level appropriate to the profession.
3. Appreciate the importance of quality and safety in healthcare.
4. Be aware of those ethical issues in healthcare relevant to the scope of the profession (including data protection issues).
5. Understand those aspects of Healthcare Psychology and Sociology relevant to the profession.
6. Be able to practise within the legal and ethical boundaries of the profession
7. Understand the obligation to maintain fitness to practise.
8. Be able to work, where appropriate, in partnership with other healthcare professionals, support staff, service users and their relatives and carers
9. Be able to demonstrate effective and appropriate skills in communicating information, advice, instruction and professional opinion to colleagues, service users, their relatives and carers.

Core Medical Physics Competence Statements (Medical Physicist as Medical Device / Physical Agents Expert)

1. Demonstrate knowledge and understanding of medical device terminology.
2. Appreciate the need for quality in healthcare and in particular the role of the medical physicist with respect to the clinically-effective, evidence-based, safe and economical use of medical devices.
3. An appreciation of the importance of patient and occupational safety and in particular the role of the medical physicist with respect to risk assessment, optimisation and protection from physical agents (ionising radiation, electromagnetic fields, electricity, laser etc) in the hospital environment.
4. Understanding relevant EU, national and local legislation and documentation regarding medical devices and risk from physical agents within the hospital environment.
5. Understand at the expert level the principles of device management including procurement, acceptance testing, commissioning, constancy testing and calibration.
6. Understand at the expert level the principles of assessment of quality in the use of medical devices.
7. Understand at the expert level the use of instrumentation for the measurement of doses from physical agents associated with patient and occupational risk.
8. Know and understand basic biomedical electronics and signal processing.
9. Able to apply research methodologies /statistical techniques used at the interface between physical and biomedical science.
10. Know and understand the basic principles of medical device design.
11. Be able to apply the principles of Health Technology Assessment to medical devices.
12. Have a basic understanding of frontier research in biomedical physics.

Status of Medical Physics and Education in Russia

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Current Situation of Medical Physics

At present the radiation oncology in Russia is lagging about 30 years behind the developed countries. There are about 140 radiotherapy departments with only 260 medical physicists (what covers only 20% of the demand) and up to 1000 radiotherapists (what is 50% of the demand). 75% of clinics have a poor level of equipment. 90% of the radiotherapy equipment has become morally and physically obsolete. There is a limited Secondary Standard Dosimetry Laboratories (SSDL) network (only 2 laboratories, one in Moscow, the other in Saint Petersburg).

Together with the above the staff qualification is not sufficient - only 10% of medical physicists are qualified medical physicists, while the remaining 90% have insufficient experience. The overall number of medical physicists is not enough to provide a full medical physics service in the country. This way the responsibilities of medical physicists in clinics are often performed by specialists who do not have education in radiation physics and medical appliances. 10% of the radiotherapy departments do not have medical physicists in its staff and the rest of the departments face a shortage of medical physicists. The hospitals do not have enough financial resources for the staff retention and efficient equipment maintenance. As a result the majority of trained medical physics graduates do not stay long in clinics (due to their small salary) and leave to other high-paid jobs.

Under these circumstances it's next to impossible to ensure the necessary radiation protection of personnel and patients and to provide the required treatment quality. Naturally this affects adversely the physical and technical maintenance of the radiation therapy and the sophisticated radiotherapy equipment efficiency (which doesn't exceed 10%), what at the end affects the quality of cancer patient's treatment. As a result of these drawbacks the accuracy of the therapeutic dose delivery often goes to 30% instead of the 5% acceptable limit. This situation leads to high radiation risk during the patient's treatment, particularly to overdose or underdose. However, due to lack of radiation accident statistics in Russia it is impossible to evaluate accidents in terms of quantity. There is an urgent need for quality assurance and quality control system.

Due to the acute shortage of medical physicists the technical upgrading of radiotherapy centers (and procurement of new equipment) fails to ensure positive results. The sophisticated equipment and cutting-edge technologies require excellent medical physics staff, which will provide innovative treatment options to the cancer patients.

Association of Medical Physicists in Russia

The Association of Medical Physicists in Russia (AMPR) makes all efforts to improve this situation. Being a non-profit organization it is involved in the IAEA/WHO TLD postal dose audit program; creates and updates the database on equipment, technologies and staff strength in russian radiotherapy departments for IAEA DIRAC (DIrectory of RAdiotherapy Centres); elaborates the radiation oncology strategy; helps the regional oncology centers to choose the equipment, dosimetry equipment included, and train the medical physicists; provides continuous professional development of medical physicists and radiotherapists in cooperation with the National Research Nuclear University "MEPhI" and N.N. Blokhin Russian Cancer Research Center; addresses Government for medical physics support. Currently AMPR made a forecast of the needs for medical physicists, in order to achieve the level of developed countries in the next 20 years (the table below):

Number of	**CURRENT AVAILABILITY**	**TODAY'S NEEDS**	**FORECAST in 10 years***	**FORECAST in 20 years***
radiotherapy departments	140	300	500	1000

medical accelerators	100	500	1000	3000
gamma apparatus	250	200	100	50
treatment planning systems	120	600	1000	3000
brachytherapy equipment	110	150	300	600
clinical dosimeters	160	400	800	2000
dose field analyzers	75	400	700	1500
medical physicists	260	1500	3500	7000
**Forecast to achieve the developed countries' level*				

Medical physics status

Part of the activities of AMPR led to the recognition of the Medical physics specialty (profession) by the Russian Education Ministry in 2000 and the recognition of the "medical physics" position in the radiotherapy department by the Health Ministry in 2009. However we still have not achieved the inclusion of the scientific medical physics specialty in the Higher Certification Commission. The latter is necessary in Russia to defend a PhD thesis in Medical Physics and obtaining of an academic degree in this field (all PhDs in this field are now classified under other specializations, like General Physics, Radiology, Radiobiology, etc).

Medical physics education

At present the traditional educational system does not provide proper training of medical physicists in radiotherapy and nuclear medicine (mainly due to lack of clinical basis in universities and their poor communication with leading Radiotherapy centers). Nominally, there are 30 Medical Physics Department (Chairs) in Russian Universities but only 3 of them (two in Moscow and one in Saint Petersburg) provide good education for medical physicists, what is not sufficient for a large country. We also feel that the educational program in Medical Physics is not in line with the modern requirements. Often, due to the shortage of qualified professors with clinical experience, other qualified clinical medical physicists deliver University lectures. One of the most important problems, seen by AMPR, is that quality assurance (QA) in radiation treatment and patient and personnel safety are not covered sufficiently in the university educational programs.

To improve this the Board of AMPR has initiated a collaboration between two of the largest educational/scientific institutions in Russia. As a result the Medical Physics Chairs of the Moscow State University *M.V.Lomonosov* and the National Research Nuclear University *"MEPhI"* are now in a transition stage to deliver a system with two educational levels: Bachelor and Master of Medical Physics.

Among its other activities the Association of Medical Physicists in Russia is strongly involved in the Continuing Professional Development (CPD) of medical physicists. Currently the AMPR and the Russian Medical Academy of Postgraduate Education, together with the Russian leading cancer centers organize courses for medical radiation physicists on a regular basis. The AMPR long-term educational experience and expertise, the clinical base of *N.N.Blokhin* Rusian Cancer Research Centre, the educational bases of the National Research Nuclear University *"MEPhI"*, and the *M.V.Lomonosov* Moscow State University make a significant contribution to the post-graduate education of medical physicists with their experienced faculty. The ESTRO courses also help to acquire appropriate level of competence.

To stabilize our efforts for improving the Medical Physics status and education we organize annual conferences and congresses on medical physics and engineering (held every five years). The III Euro-Asian congress on Medical Physics and Engineering "Medical Physics - 2010" (endorsed by IOMP) was held in Moscow, June 2010.

Statistical Information(Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Russian Federation

Population estimate, 2009	141,927,297
GDP per capita, 2009	US$15,807
Medical Physicists in Society, 2009	255

Current Medical Physics Infrastructure in Turkey

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The education scheme for Medical Physics in Turkey differs considerably from the countries of the European Union. The Turkish Medical Physics Society (TMPS) has been founded in 1988 and University based Medical Physics education increases but still there is no international harmonization of the curricula. The aim of this paper is to explain the current status of Medical Physics in Turkey.

There are 104 state universities and 53 private universities in Turkey (as per 2011). Three state universities (Hacettepe, Ankara and Dokuzeylül Universities) run Medical Physics graduate programs. These are the two years graduate programs after four years university (BSc) degree. Generally students spend their first year with theoretical and practical courses and during the second year prepare an MSc thesis.

Entrance Requirements and the MS Courses in Turkey

<u>First Stage</u> :
The basic eligibility for admission is a BSc degree in physics, related field in physical sciences or engineering disciplines. In Turkey every student must succeed a special entry exam for graduate programs (ALES).

<u>Second stage</u>:
Universities have different programs according to the need of the country. The course structure is designed to prepare the students for work in hospitals, health institutions and research in Medical Physics. The curriculum of the MSc courses in medical physics is given in the appendix. The duration of the courses is 4 semesters in 2 years (the syllabus includes lectures and practical work). The total number of courses (modules) cover obligatory and selective one and although the total number of credits changes from university to university, students

must take minimum 24 credits. The MSc thesis is completed during the 4th semester. Formal examinations are held after each semester and these are monitored by the MSc course committee and external examiner (from other departments or universities). Practical classes are carried out in the departmental laboratory and also in the radiotherapy and radio diagnostic departments of hospitals.

Third Stage

This stage is in-service training in hospital environment. The training program is aimed at providing hospital based medical physics training. At present modern radiotherapy machines and linear accelerators are being installed in different government and private hospitals in Turkey. Those modern hospitals will be the source for practical training as well as the work places for medical physicists.

Medical physicist status in Turkey has been outlined in the tables below.

Diagnostic Radiology

Totally 3000 radiology specialists work in 3594 centers in Diagnostic Radiology. Total numbers of the centers have been outlined in table-1.

Table-1: Total numbers of Diagnostic Radiology equipments in Turkey (1)

Conventional X-Ray units	Interventional Radiology	Mammo	C-arm	CT scanners	Bone densitometry
3149	181	434	66	685	250

Radiotherapy

Totally 400 clinical radiotherapy specialists work in 62 Radiotherapy Centers (1,9).

Table-2 Teletherapy units (1)

Low Energy XRay	^{60}Co	Linear Accelerator	Stereotactic (using gamma sources)
12	56	33	1

Table-3: Brachytherapy afterloading units (1)

Intravascular Brachytherapy systems	Manual	Remote
14	6	8

Nuclear Medicine

There are 132 Nuclear Medicine laboratories 166 RIA laboratories in Turkey. 350 Nuclear Medicine specialists work in these centers (2,10).

Table-4 Number of Nuclear Medicine Equipments (1,2)

Gamma cameras		(Baby Cyc.)	PET + PET-CT	Rectilinear scanners	Gamma Probes
Planar	Tomographic (SPECT)				
10	220	6	18	2	25

Table-5: Number Of Qualified Medical Physicists (1)

Radiation Therapy			Nuclear Medicine			Diagnostic Radiology			Radiation Protection and Safety:	Non-Ionising (excluding Biophysics)
MSc and BSc	PhD and above	Total	MSc and BSc	PhD and above	Total	MSc and BSc	PhD and above	Total	MSc and BSc	
78	19	97	44	3	47	10	3	13	60	15

TOTAL: 232

The needs for future in Medical physics in Turkey

The skill and inventiveness of physicists and engineers has led to the development of many methods and instruments that form a vital part of modern medicine. Many examples can be cited, including the historical application of X-rays and radionuclides for therapy and diagnosis, measurement of body’s electrical activity, electromedical instrumentation, ultrasound, design and construction of rehabilitation devices, use of lasers particularly for therapy, and advanced computer-based imaging techniques such as X-ray computed tomography and magnetic resonance imaging.

In all these and other applications of physics in medicine, medical physicists co-operate with clinicians and other medical staff in a variety of ways for the benefit of the patient. This practical demand has led to the recent launch of Medical Physics programs in some of the Turkish Universities. As a result the number of Medical Physicist is expected to increase.

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Appendix

Curricula of the MSc courses in Turkey are outlined in below:

Ankara University Medical Physics Program: (Master Degree) (founded in 2000) (ref3)

Course Number	Course Title	Credit	
		Theory	Practical/Viva
101506	Radiobiology	3	0
101507	Fundamental Mathematics on Medical Imaging	3	0
101508	Fundamental Medicine on Medical Imaging	3	0
101510	Anatomy	3	0
101511	Retrospective Dosimeter	3	0
101513	Introduction to Neutron and Reactor	3	0

	Physics		
101545	Imaging Techniques I	3	0
101549	Medicinal Imaging Techniques Application I	3	0

(PhD Degree)

Course Number	Course Title	Credit	
		Theory	Practical/Viva
102510	Advanced Radiation Detection Laboratory	0	3
102512	Radio-epidemiology Dosimeter Systems	3	0
102513	Mathematical Techniques on Medical Physics	3	0

Dokuzeylül University Medical Physics (Master Degree) (founded in 2006) (ref 6)

1st Semester Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
MDF 5001	Fundamentals of Medical Physics I	2	2
MDF 5019	Radiology Physics I	2	2
MDF 5021	Radiation Oncology Physics	2	2
MDF 5023	Nuclear Medicine Physics	2	2
MDF 5031	Quantitative Analysis Techniques for Medical Physics	1	2
MDF 5037	Radiologic Anatomy	2	0
SBE 5011	Human Body Structure and Functions	2	0
MDF 5098	Specialization	0	0
MDF 5099	Thesis	0	0

2nd Semester Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
MDF 5002	Fundamentals of Medical Physics II	2	2
MDF 5024	Radiology Physics II	2	2
MDF 5046	Radiation Protection and Radiation Safety	2	0
MDF 5096	Seminar	0	2
MDF 598	Specialization	2	0
MDF 500	Research Project	0	0

1st and 2nd Semester Optional Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
MDF 5029	Radionuclide Therapy	1	2
NÜK 5011	Nuclear Electronic I	2	2
MDF 5033	Nuclear Medicine Applications I	0	10
MDF 5035	Radiology Applications I	0	10
MDF 5039	Radiotherapy Applications I	0	16
MDF 5041	Medical Imaging Process and Analyses	1	2
MDF 5008	Brachytherapy	2	0
MDF 5010	Quality Assurance in Radiotherapy	2	0

MDF 5012	Magnetic Resonance Imaging	2	2
MDF 5014	Advanced Digital Imaging Techniques	2	0
MDF 5016	Principles of Ultrasound Imaging	2	0
MDF 5028	Radiopharmacy in Medical Physics	1	2
MDF 5030	Radiobiology	2	0
MDF 5032	Radiation Oncology	2	2
MDF 5034	TLD Dosimeter	2	0
MDF 5036	Photon Electron Dosimeter	3	2
NÜK 5016	Nuclear Electronic II	2	2
MDF 5038	Radiology Applications II	0	10
MDF 5040	Nuclear Medicine Applications II	0	10
MDF 5042	Radiotherapy Applications II	0	16
MDF 5044	Nuclear Medicine	1	2
SBE 5006	Research Techniques in Health and Analyses Methods	3	2
SBE 5034	Experimental Research, planning, executing and evaluation	4	0

Hacettepe University Institute of Nuclear Sciences Medical Physics Program (Master Degree) (founded in 2003) (ref 5)

Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
NBE 514	Radiation Physics	4	0
NBE 523	Radioprotection I	3	0
NBE 533	Radiation Detection and Measurements	2	1
NBE 543	Radiation Biology	3	0
NBE 613	Radiation Dosimeter	2	1
NBE 633	Radioprotection II	3	0
NBE 643	Radioprotection III	3	0
NBE 650	Seminar	0	0
NBE 660	Research Project	0	0

Optional Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
IST 502	Statistics	3	0
NBE 593	Special Topics in Radiation Physics	3	0
NBE 693	Radiation Applications in Medicine and Industry	2	1
NBE 573	Numerical Analyses	3	0

Other Optional Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
FM 519	Advanced Diagnostic Radiology Physics	3	0
FM 545	Imaging Techniques I	3	0
FM 546	Imaging Techniques II	3	0
NEM 551	Numerical Methods in Radiation Transport	3	0
FIZ 583	Technical Methods in Physics	3	0
FIZ 653	Radiation Physics I	3	0
FIZ 683	Radiation Physics II	3	0
FIZ 673	Biophysics I	1	0
FIZ 663	Biophysics II	1	0

Ege University Medical Radiophysics Program (Master Degree) (founded in 2005) (MSc and PhD Medical Physics Programs of Ege University are prepared in 2011) (ref 7)

1st Semester Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
0116501	General Radiophysics	2	4
0116505	Clinical Oncology I	2	4
0116516	Seminar	1	0

2nd Semester Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
0116504	Clinical Oncology II	2	4
0116518	Medical Radiophysics	2	4

Optional Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
0116509	Radioprotection I	2	0
0116508	Radioprotection II	2	0
0116511	Anatomy I	2	0
0116510	Anatomy II	2	0
0116512	General Pathology and Tumor Pathology	2	0
0116513	Computer aided Biostatistics	3	0
0116515	Biophysics	2	0
0116517	Brachytherapy Physics	2	4
0116519	Medical Imaging Systems	3	0
0116520	Fundamental radiobiology	2	0
0116521	Special Radiotheraphy Technics	2	4
0116522	Radiotheraphy Physics Applications I	0	30
0116523	Radiotheraphy Physics Applications II	0	30

University of Istanbul Medical radiophysics Program (Master Degree) (ref 4)

Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
OTF 100	Seminar	0	0
OTF 101	General Radiophysics	2	2
OTF 102	Radiation detection methods	2	2
OTF 103	Treatment planning	2	2

Optional Courses

Course Code	Course Title	Credit	
		Theory	Practical/Viva

OTF 104	Introduction to Bracytherapy physics	2	1
OTF 105	Radioprotection	1	0
OTF 106	Quality Assurance in Radiotherapy	1	1
OTF 107	Imaging Techniques	2	1

Uludağ University Medical Radiophysics Programs (Master and PhD Degrees) (ref 8)

Obligatory Courses

Course Number	Course Title	Credit	
		Theory	Practical/Viva
SAB 5001	Biostatistics	2	2
TRF 5001	General Radiophysics1	1	0
TRF 5002	General Radiophysics2	0	2
TRF 5003	Clinical Radiation onkology1	1	0
TRF 5004	Clinical Radiation onkology2	0	2
TRF 5005	Radioprotection	1	0
TRF 5006	Nuclear Radiation Detection	1	2
TRF 5007	Fundamental Radiobiology	1	0
TRF 5008	Nuclear Numerical Applications	2	0
TRF 5009	Radyodiagnosis		
TRF 5010	Nuclear medicine		

Optional Courses

Course Code	Course Title	Credit	
		Theory	Practical/Viva
TRF 5501	Biophysics	1	0
TRF 5502	General and Tumor Pathology	1	0
TRF 5503	Clinical Radiodiagnosis	1	4
TRF 5504	Clinical Nuclear Medicine	1	4
TFR 5505	Introduction to Anatomy	1	2

Statistical Information (Wikipedia, 2009; IMF, 2008; IOMP, 2009)

Republic of Turkey

Population estimate, 2010	73,722,988
GDP per capita, 2009	US$8,578
Medical Physicists in Society, 2009	105

Biomedical Engineering and Physics Education in Estonia

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Introduction:

During the early nineties, after the re-independence, Estonia had the challenge to develop its health care system. This included the health care technology and its management – in accord with the best practices and accepted standards of the Western European countries. There are long traditions of medical education and health care in Estonia, but the education in medical physics and biomedical engineering was practically absent until that time. The biomedical engineering education at Tallinn University of Technology started in 1992-1993 academic year. As a result of the bilateral agreement between Estonian Ministry of Social Affairs and Estonian Society for Biomedical Engineering and Medical Physics a Strategic Plan for Development of Medical Technology was developed (covering the period to 2015).

Motivation:

During the process of modernization of the Estonian higher education system, in line with the EU Bologna declaration, a new curriculum in Biomedical Engineering and Medical Physics (3+2 system) was developed in 2002. According to needs of Estonia, Medical Physics became an important part of the curriculum. Therefore the curriculum on Biomedical Engineering and Medical Physics (YABM02) was developed as an independent Master's level curriculum. The new Bachelor curriculum in Medical Physics was introduced in 2003 as a specialization of the Engineering Physics Bachelor's curriculum, and was accredited in 2005.

Objectives:

The main idea of the above curriculum is to enhance a quality of medical service using up-to-date medical technology and quality assurance. Important part is the number and educational level of technical staff in related areas, not only in hospitals but also in different institutional bodies connected with the health care system.

Facilities:
The Biomedical Engineering Centre is located in the building of Institute of Cybernetics. Our close neighbour is the North-Estonian Regional Hospital - the main partner for students laboratory work, student practice, course projects, graduation thesis and for scientific purposes. We have close co-operation also with East Tallinn Central Hospital.

Current Status of the Biomedical Engineering Centre:
Since 2002 BMEC belongs to the Faculty of Science as an independent structural unit. In the faculty, BMEC is responsible for teaching activities in all three levels: Bachelor, Master and Doctoral studies in Biomedical Engineering and Medical Physics. The BMEC is comprised of two Chairs: Chair of Biomedical Engineering and Chair of Medical Physics. In 2004 the BMEC was elected for three years as University Centre of Excellence. Today we have 15 students at Bachelor level, 14 students at Master level and 7 students at Doctoral level.

Teaching activities (new 3+2 system):

Bachelor degree : 3 years, 120 credits (CP), started 2004, accredited 2005
YAFB02 Engineering Physics, 2 specializations:

- Engineering Physics
- Medical Physics

Master's degree (2 years, 80 CP), started 2002, accredited 2006
YABM02 Biomedical Engineering and Medical Physics, one specialization.

PhD degree (4 years, 160 CP), started 2002, accredited 2003
YALD02 Chemistry and Gene Technology, 4 specializations:

Gene Technology, Chemistry, Molecular Technology, Biomedical Engineering and Medical Physics

Bachelor, Master and Doctoral Level:

1. YAFB02 Engineering Physics

Specialization Medical Physics [CP in the brackets]

Compulsory courses 10 CP

- YBB0050 Biomedical Engineering and Medical Physics [3]
- YBR0110 Physiological Signals and Systems [3,5]
- YBR0130 Measurements in Physiology [3,5]

Optional courses (at least 4 CP)

- YBR0100 Human Physiology [3]
- EMR0040 Basic Biomechanics [4]
- YTD0041 Biomedicine [1,5]

Practice 3 CP

Optional courses (at least 3 CP)

- EMR3180 Practical Work [3]
- YBR0120 Practical Work in Medical Physics [3]
- YFR3900 Practice [3]
- YMR3900 Practice [3]

2. YABM02 Biomedical Engineering and Medical Physics

General studies 2 CP

Compulsory courses 2 CP

- HLX8040 Foreign Language for Science and Research [2]

Basic studies 7 CP

Compulsory courses 7 CP

- YBR0080 Electromagnetic Fields and Waves [3,5]
- YBR0030 Digital Signal and Image Processing [3,5]

Practice 3 CP

Compulsory courses 3 CP

- YBB0040 Practical Work [3]

Core studies 17 CP

Compulsory courses 9,5 CP

- YBR0010 Anatomy and Physiology [3]
- EMR0050 Mathematical Modelling [3]
- YBB0010 Microwave and Optical Engineering [3,5]

Optional courses (at least 7,5 CP)

- ISC0011 Circuits, Systems, Signals [3,5]
- ITI0010 Main Course of Programming [3,5]
- YTM0011 Molecular and Cell Biology [6]
- ITV0020 Systems Programming in C [3,5]
- ITV0050 Operating Systems and Network Administr. [3,5]
- YTG0011 Gene Technology I [2,5]
- YKB3330 Biophysics [1,5]

<u>Special studies 27 CP</u>

Compulsory courses 16 CP

- YBR0050 Biological Effects of Radiation [4]
- YBB0020 Biomedical Instrumentation [4]
- YBR0040 Physiological Signal Processing [4]
- YBR0060 Physics of Medical Imaging [4]

Optional courses (at least 11 CP)

- VET8410 Physiological Control and Adaptation [2]
- YBR0090 Bioelectromagnetism [5]
- VET8400 Basic Neuroscience [2,5]
- YBB0030 Professional Workshops and Presentations [3]
- YBR0020 Biomedical Engineering and Medical Physics - Project [5]
- YBR0070 Quality Assurance in Radiology [4]

3. YALD02 Chemistry and Gene Technology

<u>Specialization Biomedical Engineering and Medical Physics</u>

Compulsory courses 10 CP

- YBX9010 Doctoral Workshop on Biomedical Engineering [4]
- YBX9020 Doctoral Seminar on Medical Physics [4]
- YXX9010 Doctoral Seminar in Chemistry and Gene Technology [2]

Optional courses (at least 15 CP)

- EMR9090 Seminar of Biomechanics [5]
- YBB9050 Laser Diagnostic Methods in Medicine [6]

- YBR9030 Biomedical Signal Processing [6]
- YBR9050 Special Course of Bioelectromagnetism [6]
- YTD9010 Special Course in Molecular Medicine [2]
- YTG9010 Molecular Cell Biology [7]
- YTM9030 Special Course in Neurobiology [2]
- YTP9020 Special Course in Biophysics and -chemistry [2]

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Republic of Estonia

Population estimate, 2009	1,340,415
GDP per capita, 2008	US$17,532
Medical Physicists in Society, 2009	60

Medical Physicists Education Training and Status in Romania

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Introduction

Medical Physics was developed in Romania many years ago, without having official recognition as a profession.

From January 2006 Medical Physics was recognized, as a profession, and was introduced in the official list with Classification of Occupations in Romania. As a consequence, regulations regarding the medical physicists have been issued by the National Commission for Nuclear Activities Control (i.e. Romanian Regulatory Body), jointly with the Ministry of Public Health (what concerns the medical practices using ionizing radiation). Alongside the Romanian Regulatory Body, the Ministry of Health has also the responsibility to issue regulations for the medical physicists involved in all medical activities, whether it is about medical practices using ionizing (or non ionizing) radiation. The EU directives and recommendations in this field have already been adopted in the country and recently a project was initiated aiming at setting-up a national register of medical physicists.

The new regulation for the Medical Physics Expert is part of the implementation of the 97/43 EURATOM Directive, and it generally follows the recommendations of the EFOMP (European Federation of Organizations of Medical Physicists). This regulation refers to the medical physicists involved in the medical practices using ionizing radiations. It contains requirements regarding the educations and training of the medical physicist, and also requirements for the accreditation of the medical physicist as an expert in one or more of the three main fields of activity: radiotherapy physics, nuclear medicine physics and physics of diagnostic radiology and interventional radiology.

Until recently, the medical physics training were done mainly on-the-job, under the supervision of a qualified person (not always a medical physicist) and also by attending several training courses abroad (particularly, with the occasion of acquisition of new installations). We would like to point out, that some of the medical physicists from Romania succeeded to become experts in their field, with national or international recognition.

Medical Physics Education Today

A specific education programme in Medical Physics in Romania can be reported starting with the academic year 1995/1996. As a result of the Romanian Government decision from July 1995, two similar (but not identical) programmes of education in Medical Physics were implemented at the Physics Faculties from the University of Bucharest and University of Iasi.

This programmes included groups of about 20 undergraduate students per year and per each university. After three years a similar programme was created as well at the University "Babes – Bolyai" of Cluj-Napoca. Following four years of education (8 semesters), in 1999, the first promotion, about 40 students, graduated (BSc) with the specialization in medical physics.

At the University of Bucharest 14 graduates are selected (from a group of about 20 graduate students) each year for a further Master Degree (MSc) study in Medical Physics, including 3 semesters (i.e., one year and a half).

Now, after the Bologna decision concerning the European unitary education programmes, a reorganization of the education and training programme was made. Thus, Medical Physics is becoming a direction of specialization (three years), followed by a Master Degree in Biophysics and Medical Physics (two years) and potentially continued with a PhD programme (three years).

The first three years create a background in Physics, Mathematics and General Chemistry. The direction of specialisation in Medical Physics includes only five specific courses and laboratories: General Chemistry, Biochemistry, Fundamentals of Biophysics, Bioinformatics, and Human Anatomy and Physiology.
In the following section, we present the Medical Physics curricula from the University of Bucharest. It has to be mentioned that this curricula is subject to future modifications aiming its optimization.

The average duration of a semester is 14 weeks and all courses consist generally of 2 hours lectures and 2 or 3 hours of seminars or practical laboratories per week.

Cycle I : General Preparation Level (3years)

Year I

1. Real and Complex Mathematical Analysis:	2 semesters; 4h/semester
2. Algebra, Geometry and Differential Equation:	2 semesters; 4h/week/semester
3. Programming Languages:	2 semesters; 4h/week /semester I; 3h/week/semester II
4. Mechanics:	2 semesters 5h/week /semester
5. Molecular Physics:	2 semesters 5h/week /semester
6. Electricity:	1 semester 5h/week/ semester
7. Optics:	1 semester 5h/week /semester
8. **General Chemistry**:	1 semester 4h/week /semester
9. Foreign Language:	2 semester; 2h/week /semester I; 2h/week /semester II
10. Sport:	2 semester; 1h/week /semester I; 1h/week /semester II

Year II

1. Electricity:	1 semester 5h/week /semester
2. Analytical Mechanics:	1 semester 4h/week /semester
3. Introduction in Quantum Mechanics:	1 semester 4h/week /semester
4. Mathematical Physics:	1 semester 4h/week /semester
5. Optics:	1 semester 5h/week /semester
6. Physical Electronics:	1 semester 5h/week /semester
7. Electronics of Circuits:	1 semester 5h/week /semester
8. Data Processing and Numeric Calculus:	1 semester 4h/week /semester
9. Fundamentals of Atomic and Nuclear Physics:	2 semester; 5h/week /semester
10. Foreign Language:	2 semester; 2h/week /semester I; 2h/week /semester II
11. Sport:	2 semester; 1h/week /semester I; 1h/week /semester II
12. **Biochemistry**:	1 semester; 4h/week /semester

Year III

1. Quantum Mechanics:	1 semester; 4h/week /semester
2. Electrodynamics:	1 semester; 4h/week /semester

3. Physics of Atoms and Molecules:	1 semester; 5h/week /semester
4. Thermodynamics and Statistical Physics:	1 semester; 4h/week /semester
5. Elements of Spectroscopy. Lasers:	1 semester; 5h/week /semester
6. Solid State Physics:	1 semester; 5h/week /semester
7. **Fundamentals of Biophysics**:	1 semester; 4h/week /semester
8. **Bioinformatics**:	1 semester; 4h/week /semester
9. **Human Anatomy and Physiology**:	1 semester; 4h/week /semester
10. Preparation of Licence Examination:	1 semester; 4h/week /semester
11. Elaboration of the Licence Project:	the last 4 weeks of the last semester

The specific courses for Medical Physics direction of specialisation (*vide supra*) and Master Degree (*vide infra*) are printed in bold fonts.
At the end of the Cycle I, the students obtain a Licence Diploma (similar with BSc), after they have developed and defended a Licence Project.

We want to point out that, as a general rule, the policy of the Faculty of Physics, from the University of Bucharest is that the first three years of study for all specialisations (Physics, Technological Physics, Computational Physics, Biophysics, and Medical Physics), should have a common trunk in their curricula, alongside the specific courses.

Cycle II: Master Degree Specialisation (2years)

Year I

*1. Solid state Physics:	1 semester; 5h/week /semester
*2. Complements of Numeric and Symbolic Calculus:	1 semester; 5h/week /semester
*3. Organic Electronic Materials:	1 semester; 5h/week /semester
*4. Plasma Physics and Lasers:	1 semester; 5h/week /semester
*5. Physics of Partial Ordered Systems:	1 semester; 5h/week /semester
*6. Thermodynamics and Statistical Physics:	1 semester; 5h/week /semester
*7.Complements of Quantum Mechanics:	1 semester; 5h/week /semester
*8. Special Problems of (Bio)mathematics:	1 semester; 5h/week /semester
*9. Introduction to Nanotechnologies:	1 semester; 5h/week /semester
10**. Bionics and Sensory Biophysics**:	1 semester; 4h/week /semester
11. **Immunochemistry and Immunobiology**:	1 semester; 4h/week /semester
12. **Principles and Systems Applied to Measurements of Physiological Parameters**:	1 semester; 2h/week /semester
13. Research and Documentation Activity for Dissertation Project (I)	

*Only three disciplines, by free choice, are to be attended by the Master students.

Year II

1. **Lasers-Medical Use**:	1 semester; 4h/week /semester
2. **Medical Imaging**:	1 semester; 4h/week /semester
3. **Medical Instruments. Complex Methods of Diagnosis**:	1 semester; 4h/week /semester
4**. Nuclear Radiation Utilisation in Medicine and Biology**:	1 semester; 4h/week /semester
5. **Biostatistics/Nuclear Medicine**:	1 semester; 4h/week /semester
6. **Radio diagnosis, Radiotherapy and Radioprotection**:	1 semester; 4h/week /semester
7. Research and Documentation Activity for Dissertation Project (II)	

At the end of the Cycle II, the students have to prepare and defend a Master Project. Some of them have the possibility to improve their education by enrolling in a PhD Programme.

We also want to emphasize that the medical physics programmes from the Universities of Bucharest and Iasi have obtained the final approval, from the National Council of Academic Evaluation and Accreditation, whereas the one from the University of Cluj-Napoca has obtained only a provisional approval of functioning.

According to the law, a final accreditation can be given only after three promotions of graduate students in Medical Physics, following a severe examination of the whole process of education and an examination of the results (records) obtained by the students.

The third cycle includes the PhD programmes.

Cycle III: PhD Programme (3 years)

1. Specialised courses, in agreement with the PhD subject:	3 semesters; 2h/semesters
2. Research activity for PhD project:	6 semesters

Further Medical Physics Training

The Medical Physics Training is performed today in the main medical research institutes and large hospitals within the cities where the universities are located (e.g.: Oncological Institutes from Bucharest and Cluj-Napoca, Institute of Public Health-Bucharest, etc.). This is done by practical work or one week training course, without having, however, a national institutional system.

Medical Physicists and Radiation Medicine Facilities

Ar present there are about 80 medical physicists working in Romania - mainly in hospitals, in activities involving radiation medicine, or in

companies performing maintenance, repair, servicing, testing and control of radiological equipment along with specialized engineers, (36 medical physicists working in radiotherapy, 22 medical physicists working in nuclear medicine, 5 medical physicists working in X-ray diagnostic and 15 medical physicists working in servicing and maintenance activities).
It has to be mentioned that besides the medical physicists from hospitals an important role in the Romanian medical system it is played by the radiation hygiene laboratories network of the Ministry of Public Health - including sanitary physicists (approximately 30 specialsist) working within the divisions of the Authority for Public Health (located in 19 counties including Bucharest) and in the Institutes of Public health from Bucharest, Iasi, Cluj-Napoca and Timisoara..

It is important to point out that now in Romania we also have experts in radiological protection for different fields of activities involving ionizing radiations, like the use of radiological equipments in medicine. At this moment (2006) about 35 persons, have been accredited by the Romanian Regulatory Body as experts in radiation protection (specifically for the use of radiological equipments in medicine).

What concerns the radiation medicine equipment used in Romania today, we can give an approximation of their number (according to the 2006 annual report of the Romanian Regulatory Body). The table bellow presents the situation of radiological equipment in use, in Romania at the end of 2006.

Radiological Equipment	No. of equipment in use
Dental Radiology	803
Mammography	116
Angiography	26
CT Scanners	110
X ray Bone Densitometry	40
Diagnostic Radiology – including, general radiology (conventional and digital), general fluoroscopy and interventional radiology	1543

Nuclear Medicine – including gamma cameras and rectilinear scanners	55
Teletherapy units – incl. Low energy X ray (< 250 KeV) and ^{60}Co units	53
Linear accelerators	4
Stereotactic (using gamma sources)	1
Brachytherapy afterloading units	6

It is also important to mention that the Faculty of Physics from the University of Bucharest includes a fully operational laboratory of Non-Destructive Control with X-ray dual-energy Computer Tomograph (CT), which can also be used as a Digital Radiography (DR) instrument able to generate both CT and DR images with a resolution of about 0.5 mm. This laboratory is available free of fees to both Master and PhD students from any University.

We have to point out also the fact that the Secondary Standard Radiation Dosimetry Laboratory within the Institute of Public Health – Bucharest (which is full member of the IAEA/WHO SSDLs Network , since 1970) , is the national Laboratory responsible for the quality audit in X-ray diagnosis and radiotherapy and is an important training center for medical physicists from Romania.

Future Perspectives and Problems

The medical physics expert according to the 97/43 EURATOM Directive is: *an expert in radiation physics or radiation technology applied to exposure, whose training and competence to act is recognized by the competent authorities, and who, as appropriate, acts or gives advice on patient dosimetry, on the development and use of complex techniques and equipment, on optimization, on quality assurance, including quality control, and on other matters relating to radiation protection, concerning exposure within the scope of this Directive*.

This definition of the medical physics expert was translated and introduced in the regulations issued by the Romanian Regulatory Body. The aim was to inform all competent authorities about the importance of the medical physicist in the medical activities involving ionizing radiations. Also this definition can give us a general idea about how the educational and training programmes should be organized. According to the provisions of the regulation regarding the medical physics expert, an important issue in the near future will be the optimization and re-evaluation of the educational and training programmes that exist at this moment.

Another important matter, for which measures should be taken as soon as possible, is the training of the medical physicists. At the moment the practical work is done poorly and most of the time the students are attending just one week training course. This is absolutely insufficient and it will not help them to become good professionals.

It will be absolutely necessary to establish an institutional and well organized system for continuous professional education and training for all medical physicists from Romania. For this purpose an important role should be played both by the Universities and by the professional associations of medical physicists (i.e., Romanian Association of Medical Physicists and the Romanian Society for Radiological Protection). A key aspect is the bilateral cooperation and agreement between local professional societies, or collaboration with professional societies from other countries, the individual mobility (either in the country or abroad) of the Romanian medical physicists, and the advantages offered by the existing international programmes in this field or in connected ones (e.g. ERASMUS).

The medical physics in Romania has evolved significantly since 1995. We can remark that now the profession of medical physics is an accredited one; we have four universities with Medical Physics programmes and also specific regulations have been issued for medical physicists involved in medical acts using ionizing radiations.

Although the changes in this field are very important there are still a lot of steps that have to be taken in order to have better professionals in this domain and better legislation and educational and training programme.

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The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Romania

Population estimate, 2009	21,498,616
GDP per capita, 2008	US$9,310
Medical Physicists in Society, 2009	253

The Inter-University Education Centre in Plovdiv, Bulgaria and its MSc Course in Medical Radiation Physics and Engineering

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INRODUCTION

Medical Engineering Education in Bulgaria begins during the 1960-ies ann Medical Physics Education during 1990-ies. A separate paper will describe these courses and their development. This paper outlines the development of an Inter-University MSc Course, which model and lecture materials were later exported to other countries

The Inter-University MSc Course was developed as a spin off of the First European Conference on Post-graduate Education in Medical Radiation Physics (Budapest' 1994), organised by Dept. Medical Engineering and Physics at King's College London with the help of EFOMP (EC Project CIPA). After the Conference the educational programmes and experience of many European countries were collected in the book 'Medical Radiation Physics - A European Perspective' [1]. This experience supported the development of a Joint-European Project ERM [2], which objective was development of one year post-graduate course (MSc) in Medical Radiation Physics (MRP). The project started in 1995 with the following Partners: King's College London - Contractor and Co-ordinator, University of Florence, University of Dublin and three Bulgarian Universities - Medical University VMI - Plovdiv, Technical University -br. Plovdiv, University of Plovdiv.

INTER-UNIVERSITY CENTRE

Medical Physics (MP) education is expensive - related to special equipment, hospital time and limited number of lecturers. This creates difficulties for organising MP courses in many countries, passing through economic constraints. The project Consortium decided that this can be overcome by co-operation between several different faculties, bringing together different expertise, equipment and skills. Due to this reason the first step of the project was to establish a new joint education structure - Inter-University Centre for Education in Medical Radiation Physics/Engineering (IUC). It was based at the Medical University - VMI Plovdiv, Bulgaria. The Centre consists of one Radiation Laboratory, Lecture Room and office. Modern computer and radiation measurement equipment was installed in the Centre. The libraries, laboratories and diagnostic/ therapeutic equipment of Plovdiv Medical University, Technical University, Dept. Atomic Physics at Plovdiv University were also used for the education process. Additionally to the EU funding, support for the Centre infrastructure was also received from the local branch of Siemens.

STAFFING AND CURRICULUM

The course Curriculum was prepared in line with the international standards and followed the UK IPEM criteria. Thirty highly experienced honorary lecturers were chosen from different Universities, Hospitals and Institutions (24 of them are with PhD and DSc, including 16 Professors). In order to arrange their contribution to the teaching process the course adopted a fully modularised structure.

All modules are taught intensively during the week, minimum 6 academic hours per day. Special syllabi, teaching materials and Lecture Notes were written for each module. The length of each module is from 1 to 3 weeks.

The newly created MSc/Diploma course consists of 12 modules, divided in two terms (one full academic year). The total length of the course is approximately 850 academic (contact) hours. The course Curriculum is as follows:

TERM 1 (September - December)

1. Basis of Human Anatomy and Physiology (c. 90 acad. hours; test assessment)
2. Radiation Physics (c. 90 acad. hours; exam)
3. Radiation Measurements (c. 90 acad. hours ; exam)
4. Radiobiology (c. 60 acad. hours, test assessment)
5. Physics and Equipment of Ultrasound, Lasers, NMR (c. 90 acad. hours, exam)

Holiday (Exams on 2,3,5)

TERM 2 - 1st part (January - March)

6. Physics and Equipment of Diagnostic Radiology (c. 80 acad. hours, exam)
7. Physics and Equipment of Nuclear Medicine (c. 80 acad. hours, exam)
8. Physics and Equipment of Radiotherapy (c. 80 acad. hours, exam)
9. Image and Signal Processing in Medicine (c. 60 acad. hours, test assessment)

Holiday (Exams on 6,7,8)

MSc thesis assignment

TERM2 - continued (April - May)

10. Radiation Protection and Hospital Safety (c. 80 acad. hours, tests, Certif.)
11. Medical Informatics (c. 30 acad. hours, test)
12. European Integration (c. 30 ac. h., test, optional)

Awarding Post-graduate Diploma in MRPE

MSc THESIS Term

Normally the work on the MSc thesis takes 3-5 months, followed by thesis defence (viva-voce).

MSc COURSE ORGANISATION

The course was developed with two levels of graduation: Post-graduate Diploma and MSc degree:

1. All students who pass all exams in the first and second term (semester) receive a post-graduate Diploma in Medical Radiation Physics (MRP).
2. All students who pass all exams with mean result above 50% receive a post-graduate Diploma on MRP plus a MSc thesis assignment. The

work on the MSc thesis follows after the end of the second term. On successful thesis defence (viva-voce) they graduate with a MSc degree in Medical Radiation Physics.

3. Attending separate modules is also possible. In this case a separate Certificate is issued.

The entry requirements for the students were accepted on the basis of minimum 4 years University education (BSc equivalent) in the following specialities: physics, applied physics, engineering physics, electronics, computer engineering, automatics engineering, or equivalent. A good command of English is also required. The Centre admits approximately 15 post-graduate students per academic year. These are registered with one of the partners - the Faculty of Physics to the University of Plovdiv.

Initially all teaching in the course was conducted in English. Later the course was delivered in Bulgarian, but the lecture notes continued to be in English.

IMPACT OF THE INTER-UNIVERSITY CENTRE

The books with Lecture Notes [3] produced for the MSc course were printed by the specially established Foundation for distribution to other courses. These are:

- Basis of Human Anatomy and Physiology;
- Radiation Physics;
- Radiation Measurements;
- Basis of Radiobiology;
- Ultrasonic Medical Instrumentation;
- Lasers for Medicine;
- Magnetic Resonance Imaging;
- Diagnostic Radiology - Physics and Equipment;
- Nuclear Medicine - Physics and Equipment;
- Radiotherapy - Physics and Equipment;
- Signal and Image Processing in Medicine;
- Radiation Protection and Hospital Safety;
- Information Technology in Medicine;
- Introduction to European Integration

The model, materials and experience from the above project were used during the development of the joint Baltic MSc course (Latvia, Estonia and Lithuania). The lecture notes of the Centre were also exported to the Czech Republic, Thailand, Costa Rica, Jamaica and UK.
The Inter-University MSc Course was the first overseas programme to obtain UK IPEM accreditation for the period its teaching was in English (1998-2003). By 2007 the IUC produced approximately 100 graduates. Currently the Centre has been moved to the University of Plovdiv and the course is restructured aiming at development of a BSc course in Medical Physics.
The information in this paper is relevant to 2007.

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Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Republic of Bulgaria

Population estimate, 2009	7,606,000
GDP per capita, 2008	US$6,560
Medical Physicists in Society, 2009	40

Actual State of Medical Physics and Biomedical Engineering Education in Poland

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I. INTRODUCTION

In this paper we intend to present the current state in education in Medical Physics (MP) and Biomedical Engineering (BME) in Poland. Education on medical physics and engineering has a long tradition in Poland [1] being linked to the history of the Radium Institute in Warsaw, which was established in 1934, following the initiative of Maria Sklodowska-Curie. In 1936 Prof. Cezary Pawlowski, one of the assistants and then collaborators of Madame Curie organized the first courses on medical physics and biomedical engineering in the Physics Department of the Radium Institute.

In 1946 the first academic course of medical engineering was opened at the Faculty of Electrical Engineering of Warsaw University of Technology. In 1951 the specialization, called shortly "Electro-medicine" was created. Until 2006 Education in Biomedical Engineering was proposed as specialization in other fields of studies e.g. mechanics, automatics & robotics, electronics.

Education in Medical Physics in Poland [2] started in 1950 with the Technical Physics specialization at the Warsaw University of Technology created by Prof. Cezary Pawlowski and at the AGH University of Science and Technology (former University of Mining and Metallurgy) in Krakow by Prof. Marian Miesowicz. In 1974 Medical Physics program has been initiated at Warsaw University and in 1979 at the Jagellonian University in Krakow (undergraduate course in Experimental Physics). In 1990 Medical Physics and Dosimetry specialization has been established at the AGH University of Science and Technology in close cooperation with the Collegium Medicum (Faculty of Medicine) of the Jagellonian University in Krakow.

The paper here was prepared using data collected from the information delivered to the candidates to the Higher Education Schools in academic year 2010/2011.

II. EDUCATION IN MEDICAL PHYSICS

In academic year 2010/2011 Medical Physics education has been offered by 12 universities and 5 technical universities in Poland (see Table 1 in an annex) in the following disciplines : Medical Physics (MP; since academic year 2008/2009), Physics (P -experimental physics), Technical Physics (TP), Biophysics (B) and in applications of Physics in Medicine and Biology (APMB).

The curricula consist of lectures, problem classes, laboratory classes, seminars and practicals. Student exchange programs, such as ERASMUS, are very successful in allowing Polish students in Medical Physics to study abroad e.g. in Denmark, Germany, Spain, UK
The implementation of EU Directive 96/29 and Directive 97/43/EURATOM created job opportunities for medical physicists, especially in Quality Control and Quality Assurance of X-Ray and nuclear medicine diagnostic equipment.

III. EDUCATION IN BIOMEDICAL ENGINEERING

The development of medicine and sophisticated medical equipment created the need for a new approach to the teaching of biomedical engineering in Poland.

Until academic year 2005/2006 education in biomedical engineering was proposed as specialization in other fields of studies e.g. mechanics, automatics & robotics, electronics. Therefore, a consortium of six technical universities- in alphabetic order: AGH University of Science and Technology (Krakow), Gdansk University of Technology

(Gdansk), Silesian University of Technology (Gliwice), Technical University of Lodz (Lodz), Warsaw University of Technology (Warsaw) and Wroclaw University of Technology (Wroclaw)- was created, in order to elaborate the new program and to apply to the Ministry of Science and Higher Education to create a new educational direction called "Biomedical Engineering" (BME). The work was supported also by Committees of Polish Academy of Sciences. The application was prepared in June 2004 and accepted in June 2006. AGH University of Science and Technology was the first in Poland to enroll the students in BME in academic year 2006/2007. In 2007/2008 all members of the consortium had their students in BME. In 2010/2011 education in BME was offered by 16 universities in Poland. Table 2 (in the annex) presents the list of institutions providing education in BME in academic year 2010/2011.

The curricula of BME education will prepare the graduates for the profession of designer of medical equipment or clinical engineer. The organization of the studies had to be consistent with the requirements of the Bologna Process which represents a commitment by forty-five European countries to undertake a series of reforms in order to achieve greater consistency and portability across their higher education systems, by harmonizing academic degree standards and quality assurance standards throughout Europe.

IV. CONCLUSIONS

Presently the main demand for medical physicists and biomedical engineers in Poland appears to be by hospitals (radiotherapy, radio-diagnostics and interventional radiology, nuclear medicine etc.) and by industry R & D.

Research in medical physics and biomedical engineering in Poland is partly supported by the Ministry of Science and Higher Education in form of grants and direct financing of universities. Some research activities are coordinated by the Polish Academy of Sciences, Department VI of Medical Sciences. Better research opportunities for students and graduates could be created through EU FP/6/7 instruments.

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Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Republic of Poland

Population estimate, 2009	38,130,302
GDP per capita, 2008	US$13,846
Medical Physicists in Society, 2009	~200

ANNEX

Table 1 List of institutions which provide education in Medical Physics (MP) in Poland

Institutions	Faculty/ Department	Discipline	Specialization
Univ. of Bialystok (Bialystok) www.uwb.edu.pl	Physics	P*	MP
Univ.of Gdansk (Gdansk) www.ug.gda.pl	Math, Physics &Informatics in cooperation with Gdansk Medical Univ.	MP*	MP
Univ.of Silesia (Katowice) www.us.edu.pl	Math., Phys. and Chem.	MP	Clinical Dosimetry; Optics in Medicine; Electroradiology
Jan Kochanowski Univ. of Humanities and Sc. (Kielce) www.ujk.edu.pl	Math.&Sc.	P	MP
AGH Univ. of Sc .&Techn. (Krakow) www.agh.edu.pl	Phys.& Appl. Comp. Sc.	MP	Dosimetry and Electronics in Medicine; Imaging and Biometrics
M. Curie-Sklodowska Univ. (Lublin) http://mfi.umcs.lublin.pl	Math., Phys. Comp. Sc.	P	Molecular and medical biophysics
Un. of Lodz (Lodz) www.uni.lodz.pl	Phys& Chem.	P	MP
Techn.Univ.Lodz (Lodz) www.p.lodz.pl	TPhys., Comp Sc.& Appl.Math.	TP*	MP
Univ.of Opole (Opole) www.wmfi.uni.opole.pl	Math., Phys & Chem.	MP	MP
Adam Mickiewicz Univ. (Poznan) http://amu.edu.pl	Physcis	B****	MP
Ignacy Lukasiewicz Techn.Univ. (Rzeszow) http://portal.prz.edu.pl	Math.& Appl. Physics	TP	Physics and Informatics in Medicine
Univ.of Szczecin (Szczecin) www.us.szc.pl	Math.& Physics	P	Biomedical Physics
Nicolaus Copernicus Univ. (Torun) www.umk.pl	Phys., Astr& Informatics	MP	MP and Comp. Appl.
Warsaw Univ. (Warsaw) www.uw.edu.pl	Physics/Inst. of Exp.Phys.	APBM*****	MP
Warsaw Univ. of Techn. (Warsaw) www.pw.edu.pl	Physics	TP	MP
Wroclaw Univ. of Techn. (Wroclaw) www.pwr.wroc.pl	Fund. Problems of Techn.	TP	Nano-engineering
Univ. of Wroclaw (Wroclaw) www.uni.wroc.pl	Physics and Astr.	TP	MP

*)MP=Medical Physics ; **) P=Physics ;***)TP=Technical Physics; ****B=Biophysics; *****APBM=Applications of Physics in Medicine and Biology

Table 2 List of institutions which provide education in Biomedical Engineering (BME) in Poland

Institutions	Faculty/ Department	Organisation (actual state)/specializations
AGH Univ. of Science and Technology (Krakow) www.biomed.agh.edu.pl	Electrical Eng., Automatics, Comp. Sc.& Electronics	Multidisciplinary School of engineering In Biomedicine (MSIB)/Medical Electronics and Informatics; Biomaterials; Biomechanics and Robotics; Bionanotechnologies; Emerging Technologies in Health Care (in English)
Bialystok Univ. of Techn.(Bialystok) www.ib.pb.edu.pl	Mechanical Engineering	/Biomechanics; Rehabilitation Engineering; Medical Materials
Czestochowa Univ. of Techn. (Czestochowa) www.wimii.pcz.czest.pl	Mechanical Engineering & Comp. Sc.	Rehabiltation Engineering; Medical Informatics.
Gdansk Univ. of Technology (Gdansk) www.biomed.eti.pg.gda.pl	Electronics, Telecomunications &Informatics	Inter-Faculty full-time studies /Informatics in Medicine; Electronics in Medicine; Chemistry in Medicine; Physics in Medicine
Koszalin Univ. of Techn. (Koszalin) www.imnitp.tu.koszalin.pl	Institute of Mechatronics, Nanotechnology& Vac. Techn.	/Implants; Medical Instrumentation; Manipulators
Krakow Univ. of Technology (Krakow) www.riad.usk.pk.edu.pl	Mechanical Engineering	/Clinical Engineering; Dental Biomechanics; Biomechanics of Injuries
Lublin Univ. of Techn. (Lublin) www.itsi.pollub.pl	Mechanical Engineering	In cooperation with Lublin Medical Univ./Computed Tomography; Magnetic Resonance; Automatics&Robotics in Medicine; Biomaterials&Artificial Organs; Medical Electronic Equipment; Informatics in Medicine
Lodz Univ. of Techn. (Lodz) http://wee.p.lodz.pl	El., Electronic, Comp.& Control Eng.	Inter-Faculty Education Centre in cooperation with the Fac. of El., Electronic, Comp.& Control Eng./Biomaterials; Biocorrosion; Biomeasurements
Poznan Univ. of Techn. (Poznan) www.put.poznan.pl	Mechanical Engineering&Management	Mechatronics/ Biomedical Engineering
Silesian Univ. of Technology (Gliwice) http://ib.polsl.pl	Biomedical Engineering	/Informatics in Medicine; Medical Electronic Equipment; Sensors and Biomedical Processing; Implants Engineering; Reahabilitation Equipment Manufacturing
Silesian Univ. (Katowice) www.ib.us.edu.pl	Computing Sc. and Material Sc.	/ Biomedical Informatics; Medical Imaging; Telemedicine and Clinical Information Systems;
Warsaw Univ. of Technology (Warsaw) www.mchtr.pw.edu.pl www.elka.pw.edu.pl	Mechatronics/ I. of Metrology&Biomed. Engineering and Electronics and Information Technology	Inter-Faculty studies provided by the F. of Mechatronics and F. of Electronics and Information Technology/Biomechanics; Biomaterials; Biomedical Sensors; Biomedical Imaging; Rehabilitation Engineering; Prostheses and Artificial Organs; Clinical Engineering; Biotechnology; Medical Informatics
Wroclaw Univ. of Technology (Wroclaw) www.wppt.pwr.wroc.pl	Fund. Problems of Technology	/Electromedical Equipment; Use of Smart Transducers and Systems for Measurement and Diagnostic in Biology and Medicine; Use Fiber Optics and Lasers in Medical Equipment; Use of Computer in Medical Diagnosis

Zielona Gora University (Zielona Gora) www.ibem.uz.zgora.pl	Mechanics; Electrical Engineering, Comp.Sc.&Telecommunic.; Biological Sc.	Inter-Faculty studies provided by three Faculties: Mechanics; and Electrical Engineering, Comp.Sc.&Telecommunic.; and Biological Sc. /Medical Informatics; Medical Electronics; Biomechanics; Biomaterias
Bydgoszcz Univ. of Tech. (Bydgoszcz) http://wm.utp.edu.pl	Mechanics	/Technical Medical Consulting; Medical Informatics
West Pomeranian Univ. of Techn. (Szczecin) www.we.zut.edu.pl	Electrical Engineering	/Biomedical and Acoustic Engineering

Radiological Physics Programme at Czech Technical University

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Introduction:

The Health Professions Act of the Czech Republic, issued in April 2004, substantially changed the Education and Training (E&T) system for Medical Physicists (MP) in the country. MPs have been recognized as “health professionals”, with well defined systems of E&T and Continuous Professional Development (CPD). The specific education of MPs now starts with a university-based master program in Medical Physics, accredited by the Ministry of Education and certified by the Ministry of Health (MH). The program has to fulfil the minimum requirements for such programs, which are laid down by the MH. An alternative way to become an MP is to graduate from a physics-oriented university master program and then pass an MH-Accredited Qualification Course on Medical Physics. Graduates of either branch are recognized as MPs who are not competent to act independently until they complete the next step – Specialized Education. Specialized Education in MP distinguishes three specializations: radiotherapy, nuclear medicine, and diagnostic radiology. The MP’s Specialized Education is under the supervision of a Specialist Medical Physicist at the home institution and under the supervision of an MP from an MH-accredited institution approved to organize mandatory theoretical and practical Specialized Education courses. After completion of all mandatory elements and prescribed practical requirements, a trainee takes the Specialization Examination before the in-specialization Examining Board of MH. CPD follows a defined credit-point system in 6-year periods. The new system reflects EC directives and international guidelines, such as those of EFOMP and ESTRO.

The minimum requirements for university programs for professional qualifications to pursue the health profession are specified in a Decree of the Ministry of Health. The requirements include: a specified amount of practical in-hospital education, background knowledge in mathematics and physics, nuclear and radiation physics, radiation detection, dosimetry and measurements, radiobiology, radiation protection, physics in nuclear medicine, diagnostic radiology and radiotherapy, quality assurance, relevant ‘health’ and ‘nuclear’ legislation, and essential medical fields such as human biology, anatomy and physiology, X-ray and cross-sectional anatomy and pathology, health ethics, and first aid.

The Czech Technical University in Prague (CTU) has many years of experience with education in dosimetry and application of ionising radiation, including medical applications. Since problems of radiation protection and medical applications of ionising radiation are a major aspect of all medical physics, most of the MP staff currently working in hospitals in the Czech Republic are CTU graduates. About 8 years ago, CTU opened a new specialization in Medical Radiation Physics, recently renamed Radiological Physics. The programme of this specialization has gradually been separated from the original Dosimetry and Ionising Radiation Application program by implementing further medicine and medical physics-related courses instead of some of the original non-medically oriented courses.

During the winter of 2005 CTU was the first university in the country to receive accreditation for its new program in Radiological Physics in accordance with the new legislation. Graduates automatically gain the status “professional qualification to pursue the health profession of radiological physicist” (as MP is described in the Czech juridical terminology).

Motivation:
In accordance with the new legislation reflecting the relevant EC directives, the Czech Technical University has prepared a new Master degree program in radiological physics, which is based on profound background knowledge in mathematics and physics. This program is organized in cooperation with partner institutions, including departments of radiotherapy, nuclear medicine and diagnostic

radiology in hospitals. Graduates automatically gain the status "professional qualification to pursue the health profession of radiological physicist".

By implementing this program, CTU has complied with the new legislation and has opened the way for recognized radiological physicists to be educated in the Czech Republic.

Objectives:
The master program of Radiological Physics aims to produce graduates who will be duly recognized as radiological physicists and will be allowed to pursue the health profession of radiological physicist in departments of medical physics, radiation oncology, nuclear medicine and diagnostic radiology in hospitals in the Czech Republic.

Duration of the Program:
According to the new education policy of the country, master programs (2-3 years as a standard) follow on from bachelor programs (3-4 years as a standard).
The standard duration of this program is three years following a bachelor study program in general physics, or equivalent.

Collaborating Institutes:

a) State Office for Nuclear Safety
b) National Radiation Protection Institute
c) Czech Metrology Institute
d) Institute of Nuclear Physics of the Czech Academy of Sciences
e) General University Hospital, Prague
f) Hospital Na Homolce, Prague
g) University Hospital Motol, Prague
h) University Hospital Hradec Kralove
i) University Hospital Na Bulovce, Prague
j) Masaryk Memorial Cancer Institute Brno

Facilities:
The ptogramm has three laboratories for measurements of fundamental properties of ionizing radiation.

Some courses are organized in close collaboration with the relevant national institutions: a) to d) above.
The basic clinical training and diploma (degree) thesis are organized in collaboration with the departments of radiotherapy, diagnostic radiology, nuclear medicine and 'radiological physics' of six hospitals in Prague and Hradec Kralove: e) to j) above.

Current Status of the Department:
Approximately 10 students per year of study are currently studying the previous program in Medical Radiation Physics, which is not officially accredited according to the new legislation but is in fact identical with the duly accredited program. Graduates will be formally recognized as soon as they have completed the Accredited Qualification Course in radiological physics which in fact will be of zero contents for them.
Three students have been accepted in the duly accredited program in the last two years, and about five more will come in autumn 2006.
Using transformation and development funds, the department has been upgrading the lab equipment (mammograph unit, ionization chambers, electrometer, special phantoms, etc.) and working on computer support for the lectures, including e-learning components.

Course Description:

1. **Advanced Mathematics and Physics:**
   The Equations of Mathematical Physics
   Mathematical statistics
   Numerical analysis
   Quantum physics
   Fundamentals of solid state physics
   Image processing and pattern recognition 1
2. **Physics of (ionizing) radiation**
   Nuclear and radiation physics 1, 2
   Nonionizing radiation-physics and technology
   Principles of application of ionizing radiation
   Nuclear technology devices
   Monte Carlo method in radiation physics
3. **Detection and Dosimetry of Ionizing Radiation**
   Fundamentals of radiation dosimetry

Detectors of ionizing radiation
Integral dosimetry methods
Instrumentation for radiation measurements
Clinical dosimetry
Metrology of ionizing radiation

4. Radiological Physics

Radiological physics-radiotherapy 1, 2
Radiological physics - X-ray diagn. radiology
Radiological physics-nuclear medicine

5. Medicine and Health Care

Fundamentals of human biology, anatomy and physiology 1, 2
Pathology, anatomy and physiology in imaging methods 1, 2
Clinical propaedeutics
Introduction to quality management in health care
Ethics in health care
Hygiene and epidemiology
Medical informatics
Biochemistry and pharmacology
Basics of first aid
Technical and health-care regulations

6. Radiation Protection

Radiobiology
Radiation protection

7. Labs and Clinical Training

Elementary (nuclear) labs
Labs on detection and dosimetry of ionizing radiation
Nuclear medicine-clinical training
X-ray diagnostics-clinical training
Radiotherapy-clinical training

8. Individual Research Training Projects

Literature survey project
Research training project 1, 2
Master degree project 1, 2

Course Structure:

Year I:

The Equations of Mathematical Physics, Mathematical statistics, Numerical analysis, Quantum physics, Fundamentals of solid state physics, Nuclear and radiation physics 1, 2, Fundamentals of radiation dosimetry, Detectors of ionizing radiation, Fundamentals of human biology, anatomy and physiology 1, 2, Clinical propaedeutics, Elementary (nuclear) labs, Literature survey project

Year II:

Image processing and pattern recognition 1, Nonionizing radiation-physics and technology, Principles of application of ionizing radiation, Nuclear technology devices, Monte Carlo method in radiation physics, Integral dosimetry methods, Instrumentation for radiation measurements, Radiological physics-radiotherapy 1, Radiological physics-X-ray diagn. radiology, Radiological physics-nuclear medicine, Pathology, anatomy and physiology in imaging methods 1, Introduction to quality management in health care, Ethics in health care, Hygiene and epidemiology, Medical informatics, Biochemistry and pharmacology, Basics of first aid, Radiobiology, Radiation protection, Labs on detection and dosimetry of ionizing radiation, Research training project 1, 2

Year III:

Clinical dosimetry, Metrology of ionizing radiation, Radiological physics-radiotherapy 2, Pathology, anatomy and physiology in imaging methods 2, Technical and health-care regulations, Nuclear medicine-clinical training, X-ray diagnostics-clinical training, Radiotherapy-clinical training, Master degree project 1, 2

Inputs needed:

Books, equipment, staff training, etc.

We welcome your comments, suggestions and support. We are very interested in your opinion on general medical knowledge and skills indispensable for a medical physicist.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Czech Republic

Population estimate, 2009	10,501,197
GDP per capita, 2008	US$20,759
Medical Physicists in Society, 2009	124

Medical Physics Education and Training in Spain

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Ex-president of the Spanish Society of Medical Physics (SEFM).
Present Chair of the National Committee of the Specialty of *"Radiofísica Hospitalaria"* (Official advisory body of the National Health Authorities.)

The Spanish Society of Medical Physics

The Spanish Society of Medical Physics (SEFM) was founded in 1974, and has been a member of the IOMP since 1975 and member of the EFOMP since 1980. At present, it has 680 members. The majority of them (446) are involved in hospital radiation physics: 104 work solely in Radiotherapy, 17 in Nuclear Medicine and the rest are involved in the four disciplines (Radiotherapy, Nuclear Medicine, Diagnostic Radiology, and Radiological Protection). 95 of the members are medical physicists in training (residents), 66 work in Medical Physics departments at medicine Universities, and finally, a few work in other fields: Metrology, Physiology, Official Bodies, etc…

Concerning the scientific activity of the SEFM, the Spanish Society has produced several outstanding scientific publications such as: A protocol for the determination of absorbed dose in External Beam Radiotherapy, Protocols on Quality Assurance in Diagnostic Radiology and in Nuclear Medicine, made in collaboration with the respective Medical Societies and the Spanish Society of Radiological Protection. Courses, workshops, official reports, etc.

The most recent publications are dealing with: recommended procedures for the dosimetry of X-Rays within the Energies of diagnostic radiology, recommended procedures on QA of Linear Accelerators, QA of Digital Mammography, and QA of Radiotherapy Planning Systems.

Since 1977, a national congress is running every two years.

Since 2000, the SEFM publishes a scientific journal "*Fisica Medica*", with three issues per year. This journal is the official journal of SEFM and it is published under the auspices of EFOMP.

The Education and Training Scheme

Since the recognition of the specialty of Medical Radiation Physics as a health profession in 1997, the profession has made great progress. It is based on the same model as the medical specialties through the resident programme system. This implies that entrance requirements, training, status and salary are similar to those of medical Specialists in the National Health Service.

So, the education and training scheme in Spain is the following:

1. **Basic Education**: 4-5 years University. Degree equivalent to master's degree, called *"licenciatura"*. In physics, engineering or similar scientific/technical matters, with a high content on physics and mathematics.

2. **Post-graduate training**. Theoretical and practical training (on job training): 3 years "resident" (like the Medical doctors specialties) in a Hospital accredited for medical physics training by the Ministry of Health.

   Only a limited number of places are available per year. The candidates must pass a national exam and only those with the best results can follow the training in the accredited Hospitals. (The present ratio is about 30 places for 250 candidates)

The 3 years' residency in the accredited Medical Physics departments involves:

a) Theoretical learning on the main topics:
   - Further studies in Radiation Physics
   - Radiation Metrology and Dosimetry
   - Measurement systems. Techniques and instruments.
   - Fundamentals of Radiobiology
   - Radiation Protection
   - Fundamentals of Human Anatomy and Physiology
   - Fundamentals of Diagnostic Imaging and Radiation Therapy
   - Fundamentals of the use of ionizing radiation in other areas: Laboratories, etc.

   This is achieved by reading recommended bibliography, attending specific courses on these topics, seminars, lectures, etc., in the hospital, or organised by the SEFM (The Spanish Society of Medical Physics) or other recognised scientific organisations. All these activities take place under the supervision of an experienced Medical Physicist who acts as a tutor.

b) Practical hospital training in the four areas concerning radiation applications.

The training time suggested for each area is:

Radiation Therapy: 1 ½ years.
Diagnostic Imaging (Radiology and Nuclear Medicine): 1 year.
Radiation Protection and others: 6 months.

During this three years period, the theoretical and practical training take place simultaneously. The trainee is incorporated gradually into the hospital's life, bit by bit increasing his/her level of responsibility in the job, and always under the supervision of the tutor.

At the end of this theoretical and practical training, the trainee shall be able to:

- Demonstrate knowledge of physical bases involved in the use of radiation for therapeutics, diagnostics and research procedures, in clinical environment.
- Demonstrate knowledge of function and characteristics of the equipment used in these procedures.
- Acquire sufficient experience to act independently.

3. **Qualification as Specialist in Medical Physics:** *"Título de Especialista en Radiofísica Hospitalaria".* Certificate issued by the Ministries of Health and Education. (Royal Decree 220/1997 and Royal Decree 183/2008. Official Gazette of the Spanish State.) In the latter one, the qualification of Medical Physics (*Especialista en Radiofisica Hospitalaria*) is considered equivalent to Medical Physics Expert, as defined in the EU Directive 97/43 EURATOM.

   At the end of the three years, if the assessment of the training is positive, the trainees apply for the certificate. This certificate allows them to work as Medical Physicist in four areas of competence: Radiotherapy, Diagnostic Radiology, Nuclear Medicine and Radiation Protection. In Spain, three Royal Decrees on Quality Assurance in Nuclear Medicine (1841/1997), Radiotherapy (1566/1998) and Diagnostic Radiology (1976/1999) were issued to fulfil the EU Directive 97/43 EURATOM.

   Medical physicists have the necessary knowledge to plan and apply all radiation physics techniques used in diagnosis and treatments in which patients are exposed to ionizing radiation. They are also trained to perform quality control of installations and equipment used in such tests and treatments, ensure radiation protection for anyone who may be exposed to radiation in medical settings, and to carry out research in all related areas. The head of any Radiation Protection Department in a National Health Service hospital must be a medical physicist.

Continuing Professional Development (CPD)

In 2000 the SEFM set up a Continuous Professional Education Program, credit point based, following the EFOMP's recommendations. A National Professional Register of *"Especilistas en Radiofísica Hospitalaria"* has also been created. Only SEFM members are included in it and registration is voluntary. The Spanish national registration scheme has obtained EFOMP full approval in 2002 and it has been renewed in 2008.

Organisation of Training Courses

The Spanish Society of Medical Physics (SEFM) organizes two kinds of courses:

1. **The "basic courses"** mainly targeted to Medical Physicist in training. The aim of these courses is to provide the theoretical background to complement the 3 years of practical training carried out in the Hospitals. The "basic courses" are structured as a single course (around 145 hours) called ***"Fundamentos de Física Médica"*** which is composed by 9 self-consistent "modules".

   Apart from that, a course on Physiology and Anatomy for Medical physicists is also organized, also aimed to Medical Physicist in training. This course is running every two years from 2002. These courses are listed in the table 1 below.

   Even if no courses are mandatory by Law to obtain certification, they are strongly recommended by SEFM, and actually, more than 95% of the Medical Physicists in training have attended the Basic Courses and a few CPD courses during their training period.

Table 1. Basic Courses. TITLE OF THE COURSE	**DURATION**
Module1: Radiation measurement: Radiation interaction. Radioactivity. Radiation Quantities and Units. Theory of the measure: Uncertainties, errors, tolerance and action levels. Radiation measurement systems.	3 days

Module 2: Diagnostic Radiology X-Ray Physics principles. Equipment. Quality assurance.	2 ½ days
<u>Module 3: External Radiotherapy (I)</u> Treatment equipment. Measurement equipment. Beams characterization. Measure of absorbed dose (TRS398 protocol and others). Quality Assurance	2 days
<u>Module 4: External Radiotherapy (II)</u> Clinical dosimetry. MU calculations. RTPS: Calculation algorithms for photons and electrons. Quality Assurance.	2 ½ days
Module 5: Brachytherapy Radioactive sources. Calibration equipment. Dose measurement(TG43). Implantation systems. Clinical dosimetry LDR, HDR, PDR. Quality Assurance.	2 days
Module 6: Nuclear Medicine Activity measurement equipment. Diagnostic equipment. Patient dosimetry. Quality Assurance	1 ½ days
Module 7: Radiobiology and principles of Oncology Radiation effects at molecular and cellular level. Models of cell survival curves. Evaluation of the radiological risk. Tumor classification. Pathway dissemination of cancers. Epidemiology.	2 days
Module 8: Radiation Protection RP in Radiotherapy, in Diagnostic Radiology, in Nuclear Medicine. **Shielding calculation. Waste management. Legislation.**	2 days
Module 9: Non-Ionizing Radiation Ultrasounds and Magnetic Resonance. Physics principles. Image formation. Equipment. Quality assurance	3 days
<u>Basic course of Anatomy and Physiology for Medical Physicists.</u>	2 ½ days

2. **The CPD (Continuing Professional Development) Courses**. Mainly addressed to Medical Physicists experienced, but attendance is also allowed for Medical Physicist in training during their last period of training. These courses are listed in the table 2 below.

Table 2. CPD Courses. **TITLE OF THE COURSE**	**DURATION**	**EXAM** (yes/no)	**FREQUENCY**
MonteCarlo Simulation in Medical Physics	2 ½ - 3 days	No	In 1997 and every 2 years from 2005
"In vivo" dosimetry in External Radiotherapy	3 days	No	Every 2 years from 2002to 2006
Clinical Radiobiology	3 days	Yes	2004
Radiosurgery	3 days	Yes	Every 3 years from 2001 to 2005
Dosimetry in Brachyteraphy	3 days	No	In 2002 and 2010
Measurement and calibration of Ionizing radiations	3 ½ days	No	Once a year from 2002 to 2004
Intravascular Brachytherapy	2 days	No	2003
Quality Control on RTPS	3 days	Yes	Every 2 years from 2005
IMRT	3 days	Yes	Once a year from 2008
Digital Radiology	3 days	Yes	Every 2 years from 2002
CT. Quality Assurance	3 days	Yes	Every 2 years from 2001 to 2005
Linacs. Quality Assurance	3 days	Yes	Every 2 years from 2008
Ultrasounds. Quality Asurance	3 days	Yes	2003 and 2009

Medical Physics Departments
In Spain, hospital physicists can be employed in both public and private centres. There is no single model of organisation in medical physics departments.

The largest centres are public and usually have got departments of Radiotherapy, Nuclear Medicine and Diagnostic Radiology. Approximately 65% of medical physicists work in independent Medical Physics departments, which cover the four disciplines of Radiotherapy, Nuclear Medicine, Diagnostic Radiology and Radiological Protection.

Of the remainder, some physicists only work in one discipline within a medical department (Radiotherapy, Nuclear Medicine, etc); others work in radiological protection departments mainly covering radiological Quality Assurance.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Kingdom of Spain

Population estimate, 2009	46,030,109
GDP per capita, 2009	US $29,651
Medical Physicists in Society, 2009	~750

Education and Training of Medical Physics in Brazil

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Introduction

During the last decade the field of Medical Physics in Brazil has substantially increased, due to the acquisition of new equipment and to the introduction of new imaging technologies. The area of Radiotherapy (RT) and Nuclear Medicine (NM) is well established since many years, however the improvement in the area of Radiodiagnostic (RD) is quite recent.

In 1998, the Minister of Health published a norm regulating the use of ionizing radiation in medicine called *"Directives of Radioprotection in Medical and Odontological Radiodiagnostic"*. One of the main requirements of this norm is the mandatory implementation of Quality Assurance Programs in all radiology departments. Since then, understanding the absence of Medical Physics Curriculum in any of the Universities in Brazil, 11 universities have taken the initiative to design such a curriculum in the level of Bachelor degree (this way supporting the need of producing trained manpower in this area).12 courses conduct research in areas related with Medical Physics (at MSc and PhD level). There are also some Residency Programs in RT (11), NM (1) and RD (4) offering annually a total of 24 places.

Courses´ description

- **Bachelor degree**

The Bachelor degree aims to produce graduates with a strong background in physics with a special emphasis on Medical and Radiation Physics, who will aim at employment in Hospitals, Research or Industry. The Brazilian Bachelor programs are not standardized, however they offer a curriculum with a duration ranging from 4 to 5 years.

The basic curriculum, is structured on 8 periods of 4 months each. Some programs offer one year more of practical work on the hospitals. The general course structure is shown on table 1.

1º Period	**2º Period**	**3º Period**	**4º Period**	**5º Períod**	**6º Period**	**7º Period**	**8º Period**
Calculus I	Caculus II	Calculus III	Methods of Theoretical Physics	Radiation Physics I	Quantum Mechanics Concepts	Ultra-sound	NMR
Physics I	Physics II	Physics III	Physics IV	Practical Nuclear Instrumentation	Radiation PhysicsII	Applied Statistics	Graduation Project
Experimental Physics I	Experimental Physics II	Experimental Physics III	Experimental Physics IV	Radiobiology and Photobiology	Practical Radioprotection I	Practical Radiodiagnostic	Practical Radiotherapy
General Physics Topics I	Fundamentals of Celular and Molecular Biology I	Fundamentals of Celular and Molecular Biology II	Modern Physics I	Thermodinamics and Statistical Physics	Practical Radioprotection *II*	Practical Nuclear Medicine	Computers Applied to Medicine
XXX	Applied Medical Anatomy	Computer Methods in Physics I	Biophysics	Human Physiology	Practical Radioprotection III	XXX	XXX

Table 1: shows the basic structure of the Bachelor courses in Brazil.

Table 2 below shows the institutions´names, the year the course has started, the number of students that already graduated, the number of students still enrolled in each university, the total number of hours of theoretical classes and of practical work.

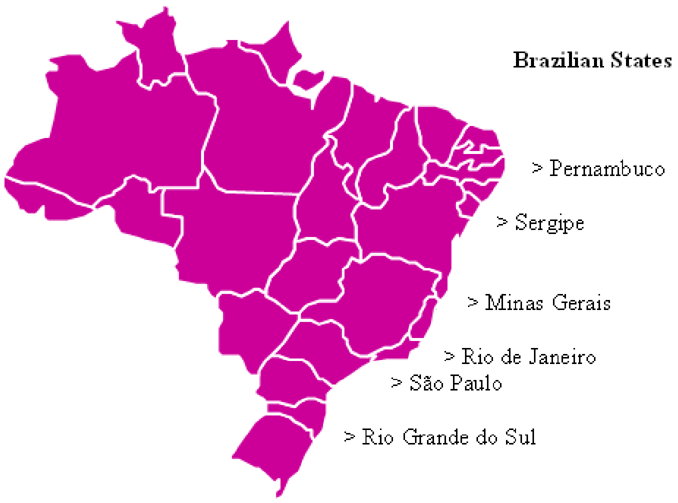
Legend:

UFS = Federal University of Sergipe

Institution	Starting year	Number of students graduated	Present number of students	Theoretical (number of hours)	Practical (number of hours)
UFS	2001	7	141	2370	435
UNIFRA	2001	22	120	2715	285
UNICAP	?	?	?	?	?
PUCRS (+ 1 semester)	1990	104	147	2910	270
PUCSP	1998	?	?	?	?
UNESP	2003	0	152	2300	750
UNICAMP (+ 2 semesters)	2003	0	90	2250	1080
FFCLRP	2000	42	194	2130	930
UFRJ	2000	14	100	1860	1170
FTESM	2000	16	74	2360	680
USP	?	?	?	?	?

UNIFRA = São Francisco University (RGS)
UNICAP = Catholic University of Pernambuco
PUCRS =- Catholic University of RGS
PUCSP = Catholic University of São Paulo
UNESP = University of São Paulo in Botucatu
UFRJ = Federal University of Rio de Janeiro
FTESM = Souza Marques Technico-Educational Foundation
USP = University of São Paulo
UNICAMP = State University in Campinas (SP)
FFCLRP = Ribeirão Preto State University
? = information not available

Brazilian map below shows the states´ locations in the country.



- **Post-Graduate Courses:**

With respect to the number of Post-Graduate courses, the distribution is as follows: 4 in São Paulo, 5 in Rio de Janeiro, 1 in Minas Gerais, 1 in Pernambuco and 1 in Sergipe. These courses are at MSc and PhD level, however none of the courses is specific on Medical Physics. The degree is obtained in research areas related with Medical Physics. The main Research Areas are:

  - Applications of Nuclear Technology
  - General Physics
  - Physics Applied to Medicine & Biology
  - Applied Nuclear Physics
  - Radioprotection & Dosimetry
  - Science & Radiation Technology
  - Minerals & Materials
  - Health Sciences
  - Dosimetry & Nuclear Instrumentation
  - Nuclear Biosciences.
  - Public Health

- **Residency Programs:**

Some institutions also offer Residency Programs. They are: 11 in RT, 1 in NM and 4 in RD. The total number of students admitted each year, per area, is:

- Radiotherapy: 10 in São Paulo, 4 in Rio de Janeiro and 1 in Minas Gerais.
- Nuclear Medicine: 2 in São Paulo.
- Radiodiagnostic: 3 in São Paulo, 2 in Rio de Janeiro and 2 in Rio Grande do Sul.

Conclusion

It can be seen that most of the Brazilian Medical Physics are quite recent. The number of students already graduated is around 200. On the other hand, the total number of students still in the universities is more than 1000. Some data is missing because we got no information from the courses´ directors. It can be concluded that in a near future, more than 1000 professional will be able to supply the need for Medical Physicists in Brazil.

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Federative Republic of Brazil

Population estimate, 2009	192,098,152
GDP per capita, 2008	US48,295
Medical Physicists in Society, 2009	~ 400

Experience in Medical Physics and Biomedical Engineering for Radiation in Cuba

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Introduction

The National Health System provides free service for all citizens. It has a three- layered structure of the medical assistance:
Elementary (includes 14434 Consult rooms and 436 polyclinics),
Secondary (with 284 hospitals from which five are National and 43 specialized), Tertiary (12 specialized institutes).
The Health System counts 7.3 beds and 6 physicians and paramedics for each 1000 inhabitants. The newborn mortality rate is 6.2/1000 born alive. (1)
Important contributions from the past in the life, physical, and medical sciences along with advances in engineering, support the above mentioned statistics. Medical Radiation Physics and Biomedical Engineering are in the core of this scientific development.

Medical Radiation Physics had its origin in the 1930s when eight x-ray systems were imported in the country. In the 1950s Radio and Cobalt therapy were introduced. The Oncology and Radiobiology Institute and the Scientific Research Centre were founded in the 1960s, a milestone for the development of nuclear medicine in Cuba (2,3). Nowadays radiodiagnostic services are available all over the country, that includes fixed installations, mobile,, fluoroscopy, and mammography and among others (4). Six Computed Tomography (CT) departments, nine Nuclear Medicine (NM) with gamma cameras and four Magnetic Resonance (MRI) offered services to the 14 provinces as of 2004.

The government is making major efforts to develop human resources, update technology and support research projects related to the state of the art in Medical Radiation Physics. A more detailed description of these topics is included in the following items.

Medical Physics/Engineering Education and Training in the country

A master degree program in Medical Images Technologies (MIT) is offered, beginning in 2005, by the National Program for Medical Images in Cuba. Its basic curriculum is as follows:

Table 1: *Subjects of the Master Program on MIT*

Basic Subjects	Applied subjects
Radiation Physics	Research Methodology
Mathematic	Programming and Networks
Probabilities and Statistic	Digital signal processing (DSP)
General Medicine	Digital Image Processing (DIP)
	MATLAB
	Management
	Biomedical Instrumentation
	Picture Archiving and Communication System (PACS)

The candidates for this program are selected students coming from Nuclear Physics, Nuclear Engineering, Telecommunications and Electronic Engineering. Electronics engineers already working as Clinical Engineers are also welcome [(5)].

A Diploma of MIT is also offered by the same team of professors. Nevertheless, the students who attend this program are graduated candidates from the same careers but who already have positions in the Cuban Health System installing and providing maintenance to the new technology acquired for radiotherapy, laser and stereotactic surgery, among others.
The subjects included in this course are [(6)]:

Table 2: *Subjects in MIT Diploma*

Diagnostic by Image Techniques	Applied subjects
Ultra Sound (US)	Research Methodology
X Rays	MATLAB
Mammography	DSP and DIP
Radiography	Image Transmission
Computerized Axial Tomography (CAT)	Laser in Medicine
Gamma Camera	Hospital safety
Magnetic Nuclear Resonance	Quality and Maintenance

Other master degree programs related to Biomedical Engineering have been offered in Cuba by different universities and centres: "Jose A. Echeverria" Polytechnic Institute (1998 – up today), Central University of Las Villas (1996 - 2000), and Neuroscience Centre (2000 – up today). The courses are designed mainly for engineers. Table 3 shows a selection of the subjects included in these programs (7)

Table 3: *Masters in Biomedical Engineering*

Subjects related to Mathematics	Life Subjects	Management Subjects	Signal, Images and Instrumentation
Advanced Mathematics	Biology	External Inspection for Medical Equipment	Bio-instrumentation
Data Bases	Molecular Biology	Systems for Biomedical Assessment	DSP
Medical Informatics	Genetic		Telemedicine
Neural Networks	Biotechnology		DIP
Artificial Intelligence	Laser in Medicine		Robotics
Advanced topics on Informatics	Artificial Organs		Systems for Radiotherapy
Telematics			

Professionals graduated from Physics, Nuclear Physics and Nuclear Engineering who are employed in Medical Physics or Radiological Protection in secondary and tertiary centres of the Health System must attend the curriculum for the Diploma on Radiotherapy (RT) or Physical Aspects of NM to obtain their work licences. Table 4 shows the subjects included in these programs (8).

Table 4: RT and Physics Aspects in NM Diplomas.

RT	Physic aspects in NM
RT Equipment	Introduction to the physic aspects in NM
Accelerators	Working principles for NM equipment
Dose planning in RT	Acquisition Methods and IDP
Advances in RT	Assessment and Control Quality in NM
Quality Assessment in RT	Monte Carlo Method in NM
	NM Techniques
	Clinical Dosimetry
	Radioprotection and Licence procedures

The above mentioned Diplomas are supervised by a group of prestigious professors from the Health Ministry and the National Centre for Nuclear Safety.

The Institute for Applied Sciences and Technology (IAST), the university responsible for the careers of Nuclear Physics, Nuclear Engineering and Nuclear Chemistry in Cuba, in collaboration with the International Agency of Atomic Energy (IAEA) and a group of research and health centres in Cuba and Spain, offers a master in Medical Physics for graduated student from the above specialities. The program is listed in Table 5 (9).

***Table 5**: Master in Medical Physics.*

Basic Subjects	**Image Techniques for diagnostic**	**RT**	**Dosimetry and Radiological Protection (RP)**
Radioactivity elements and interaction of ionizing radiation (IR)	Introduction to NM	Physical bases of RT	Dosimetry and RP instrumentation
Method for measuring IR	Applications of Radionuclide Techniques	Quality Control in RT	Physical principles of dosimetry
Applied electronics and nuclear instrumentation	NM instrumentation	Digital techniques for RT planning	RP principles in medical practice
Radiobiology principles	Single Photon Emission Computed Tomography (SPECT)	Neutron therapy	Clinical dosimetry in MN
Anatomy and Physiology principles.	Positron Emission Tomography (PET)		RP in NM
Ethics	Monoclonal antibodies in NM		Clinical dosimetry in Teletherapy
Information Technology	Physical Principles of Radiodiagnostics		Clinical Dosimetry in Braquitherapy
Nuclear analytical techniques in human health	Quality Control in Radiodiagnostics		RP in RT
Monte Carlo method in Medical Physics	Ultrasound techniques		Shielding calculations in RT
Laser applications in clinical practice.	MRI		Clinical dosimetry in Radiodiagnostic
	DIP		RP in Radiodiagnostic Shielding calculations in Radiodiagnostic Radiological emergencies and treatment for the acute irradiated person
			Low - dose dosimetry

There is some previous experience prior to this master program. Two diplomas in Medical Physics Fundamentals and Medical Physics were offered beginning in 2000 and a Master Program in Nuclear Physics beginning in 1996 and continuing up to this date with some reference to medical physics. This last program has been evaluated as an excellence master degree by the Highest Education Ministry. These programs have many common subjects with the current Medical Physics Master.

IAST is also responsible for developing the PhD Programs in Medical Radiation Physics / Engineering. Because of the scientific development of the associated technologies, the government reinforces the PhD programs in this field.

Cuba also offers Biomedical Engineering in three universities belonging to the Ministry of Highest Education since 2004. There are 40 students each year attending this program in each university. The basic curriculum is similar to the corresponding master degree program but with a typical university level(10). Furthermore, the Public Health Ministry has created the Health Technology Career in their Medical Universities, to train specialized personnel responsible for maintenance and repair of biomedical equipment installed in the country. Radiophysics is one of these specialities.

Status of profession

Up until 2004, 5 to 20% of the professionals graduated from Physics, Nuclear Physics and Nuclear Chemistry found positions in the health systems (2), while 10% of the graduates from Nuclear, Control Systems, Telecommunications and Electronics Engineers worked with the responsibility for the maintenance and repair of biomedical equipment. All so, until that date, about 70 medical radiation physicists were occupied in tasks related to conventional radiology (MRI, NM, RT, RP, among others), at specialized hospitals and tertiary centres. A similar number of professionals, (medical physicists, biologist and engineers) worked at research centres, universities, a centre for isotope production and centres where the main activities are: regulatory functions, supervision, control, protection or dosimetry calibration. As a complement, about 100 engineers and computer scientists have been working in technical supervision, maintenance, repairing, management, innovation, research and development of the biomedical technology installed in health and research centres and their technical support: interfaces, networks and software in the area of Medical Physics [11].

The number of professionals related to Medical Radiation Physics /Engineering has increased in Cuba in the last two years. This is one of the results the creation of the National Program on Medical Images. Other important results are the implementation of updated equipment for almost all the medical image techniques, as well as, the beginning of a telemedicine network construction. This network will have the capibility to link all the National Health System, universities and research centres in Cuba in the near future. This effort will contribute to the improvement of all the Cuban medical images services in the future.

The increase in the number of students who completed their education in Nuclear Physics, Nuclear Engineering and Nuclear Chemistry and who are employed in the Health System is 50 % since 2004 Their work is related to Radiodiagnostics, NM, RT and RP (20 per years approximately, among the three specialities). Furthermore, each year 200 graduated engineers have been employed with Optics and Lasers in Medicine, contributing to advanced medical technologies or working directly in the implementation of the National Net on Medical Images in the last two years.

It is important to mention some relevant research results obtained in the last 10 years as a consequence of the parallel Medical Physics and Bio-Medical Engineering development in Cuba:

- The construction of three Cuban tomographs for MRI.
- The implementation of a Transmission System for Digital Medical Images.
- The development of a Dosimetry System for specific patients.
- The production of software for manipulation and processing images in NM.
- The production and evaluation of Cuban monoclonal antibodies, labelled with radioactive isotopes.
- The design of shielding for hospital installations.

- The development and validation of a method for activity optimisation in NM.
- The construction of detectors for digital radiographic images
- The production of national radiopharmaceuticals.
- The design and validation of relative methods for cerebral blood flow quantification.
- The dose optimisation in collimated field of high energy gamma radiation [12].

The number of PhD's in Medical Physics is now growing in Cuba. These specialized professionals are obtaining their education either completely in Cuba or in sandwich programs in collaboration with institutions from Brazil, Mexico, Argentina and the European Community. Similarly, the formation of PhD in technical sciences derived from Biomedical Engineering is also promoted in the country in collaboration with doctoral programs from universities in Spain, Canada, China and Belgium, among others.

New professional development at present

Today, Cuba has benefited from the participation in some important projects of Medical Radiation Physics / Engineering supported by the IAEA and other organisations. The participants are some research centres, universities, hospitals and Institutes, in collaboration with their homologues in other countries from Latin America and the Caribbean. The most relevant projects are the following [13]:

- ARCAL XXX for improving quality assessment in clinical dosimetry for RT.
- ARCAL L Strengthening the master of Medical Physics degree.
- ARCAL LII about preparation, quality control and validation of radiopharmaceuticals on monoclonal antibodies.
- ARCAL LIII for quality control in the repair and maintenance of NM Instruments.
- ARCAL LVIII for improving the quality assessment in RT.
- ARCAL LXXIII for developing a Regional Telemedicine Network
- ARCAL LXXXIII for strengthening the performance of professionals in the Medical Physics Field

- A project supported by IAEA for the development of a quantification method for cerebral blood flow using SPECT.
- A project supported by CNPQ in Brazil and Cantabria University for the study of IR influence over DNA.
- A Project with collaboration of Salsgrenka and Pernambuco Universities to analyse image quality variability in paediatric NM and compression-transmission of digital medical images in CT and MRI
- A project in collaboration with Valencia University to develop a micro-gamma camera
- An Alpha network project to develop medical instrumentation of high technology which has been able to Cuba the construction of a band detector for mammography.

The Cuban Ministry of Science, Technology and Environment also support some projects in Neurosciences, among other research lines.

The future of the profession

For the next 5-10 years The National Health System requires around 600 engineers and physicists in Cuba to complement the work of 9000 doctors that are using the new biomedical technologies in areas such as: medical equipment industry, research, biotechnological and pharmaceutical industry, the primary, secondary and tertiary health centres and electro medical repair shops [11].

The Cuban priorities related to Medical Radiation Physics / Engineering will be to develop new medical equipment, the implementation of advanced technologies for diagnostic and therapy, and to develop new software [11].

The country aspires to create integral centres for medical diagnostic imaging, in collaboration with other countries of Latin America, in near future. These centres will be distributed among all the provinces. Technologies such as SPECT, CT, MRI, and Ultrasound, and others, will be available to all the Cuban citizens, very near to their homes. Another goal is to reach 2 % of all the engineering students in Cuba for a career in Biomedical Engineering, in the next 5 years. This will be 24 per million inhabitants, around 268 students [(11)]. Furthermore, 40 students per year will be studying Nuclear Physics, Nuclear

Engineering and Nuclear Chemistry. 50 % of them will receive employ in the National Health System or in research centres associated to Medical Physics. The other important aim will be to increase the master and PhD number in Medical Radiation Physics and others associated technical sciences.

A final important target for Cuba is its contribution in the development of medicine in Latin America and the Caribbean. For that reason, the country will continue giving support to these developing countries by our specialists, professors and technologies.

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Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Republic of Cuba

Population estimate, 2008	11,451,652
GDP per capita, 2008 (international $)	$9,500
Medical Physicists in Society, 2009	50

Professional Training in Medical Dosimetry in Morocco

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Medical dosimetrists in Morocco work in the interface between the medical doctors, the medical physicists and the technologists who operate the radiotherapy equipment. The dosimetrists also have an important role in the training of technologists and in the programmes for quality assurance. They have a high level of responsibility for the optimisation and coherence of treatment planning. The status of dosimetrists in Morocco is not yet recognized (what is also the case with the medical physics profession). The Moroccan Association of Medical Physics has recently initiated procedures for the recognition of the profession of medical physics.

The private and public centres of oncology in Morocco have a limited number of medical physicists (approximately 20 before 2005) and increase of the numbers of specialists is required.

This provides an opportunity for the creation of a professional discipline in the university (in collaboration with other professional centres) The proposed training (formation) program is outlined below.

The requirements for acceptance include basic education of DEUG Physics (bac+2): 2 years in university, as well as continuing education. radiology technicians can also apply for this training.

The duration of training is of one year, divided in two semesters. Each semester is composed of 8 modules (1 module=90 hours). The training has been realized in collaboration between the Faculty of Sciences of Rabat, National Institute of Oncology and two private centres of oncology, So far two alumnae have produced 42 persons with initial and continuing training. The trained students have been recruited by national centers of oncology.

The theoretical courses are delivered in the Faculty of Sciences of Rabat and the practical training in the National Institute of Oncology and private centres.

A commission was formed for selecting and supervising students. The diploma is a Professional Sciences Degree.

The teaching programme is described in the table below.

Semester	**Modulus**	**Hours**
First semester	*Physics on the basics of radiation *Dosimetry principles	90
	* Biological and medical basics	100
	*Language of computer programming *Numerical methods of calculation	90
	*Radioprotection * Basics of statistical methods of detection *Techniques of communication	90
Total		370
	*Sciences of computer applications *Biomedical instrumentations *Medical imaging	90
	*Sciences and techniques required in radiotherapy: electronic signal and image treatment	90
	*Project in specialized disciplines and report	105
	*Training period in hospital	105
Total		390

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Kingdom of Morocco

Population estimate, 2009	31,993,000
GDP per capita, 2008	US$2,827
Medical Physicists in Society, 2009	

Medical Physics in Ethiopia – Gondar University New Bachelor of Applied Physics Program

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Introduction:

Ethiopia is a country in East Africa. The Ethiopian government has given attention to the expansion of education programs in the country as a means of poverty eradication. To meet this, it has recently opened six Universities. Gondar University is one of those (fully opened in 2004). It has a number of faculties: Science faculty, Medical and Health Science College, Social Science and Humanities, Business and Economics.

Motivation:

Understanding the absence of Medical Physics Curriculum in any of the Universities in the country and taking in to account of the need of producing trained man power in Medical and radiation physics, the department of physics, Gondar University, has taken the initiative to design such a curriculum. This will be the first program in Medical and Radiation physics in the country.

Objectives:

The Bachelor of Applied Physics is to produce graduates with a strong background in physics with a special emphasis on Medical and Radiation Physics to find employment in Hospitals, Research or Industry. Students will gain knowledge in areas of Radiation physics, Medical Imaging and Radiation Protection.

Duration of the Program:

According to the new education policy of the country this program is intended to take three years

Collaborating Institute:

The National Radiation Protection Agency.

Facilities:
The University has a Medical College with a large University Hospital. We expect the hospital to be supplied (by donor organizations and the National Radiation Protection Agency) with the equipment necessary for training

Current Status of the Department:
Currently the department has three staff members and an additional four have just been recruited. We also expect help from expatriate staff from the Volunteer Service Overseas (VSO) through the Ministry of Education. The department has accepted the first 40 students in this program in 2004.

Course Description:

Core Physics and Mathematics:

5. Mechanics and Heat
6. Electricity and Magnetism
7. Modern Physics
8. Thermal and Statistical Physics.
9. Classical Mechanics
10. Quantum Mechanics
11. Physical Optics
12. Electrodynamics.
13. Nuclear Physics
14. Electronics.
15. Solid State Physics
16. Physics Laboratory (I,II &III)
17. Applied Mathematics (I,II &III)
18. Computer Programming (I&II)

Medical Physics Courses

19. Introduction to Physiology and anatomy.
20. Radiation Therapy
21. Radiation Physics
22. Medical Imaging with Ionizing Radiation
23. Medical Imaging with Non-Ionizing Radiation

24. Radiobiology and Radiation Protection
25. The Physics of x-ray diagnostic radiology.
26. Practical and Projects in the University Hospital.

Course Structure:

Year I:

Mechanics and Heat, Electricity and Magnetism, Modern Physics, Applied Mathematics I and II (calculus I and II),Physics Laboratory I and II, Computer I and II, Sophomore English, Research Methods.

Year II:

Classical Mechanics, Quantum Mechanics, Statistical and Thermal Physics, Electrodynamics, Electronics, Solid State Physics, Nuclear Physics, Physical Optics Physics Laboratory III, Radiation Physics.

Year III:

Medical Imaging with Ionizing Radiation, Medical Imaging with non Ionizing radiation, Radiobiology and Radiation Protection, radiotherapy The Physics of X-ray diagnostic Radiology, Practical in the University Hospital, Mini Projects

Inputs needed:

Books, equipment, training of staff

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)

Federal Democratic Republic of Ethiopia

Population estimate, 2008	79,221,000
GDP per capita, 2008	US$333
Medical Physicists in Society, 2009	Not yet IOMP member

Medical Engineering and Physics Education in Sudan –
Programme of the Academy of Medical Sciences and Technology

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The Academy of Medical Sciences and Technology in Khartoum, Sudan runs an Undergraduate programme on Biomedical Engineering. The elements of its Curriculum are listed below:

First Year Semester (1)
Engineering Math – I
Scientific English – I
Religious Study
Arabic Language
Engineering Drawing
Computer use and application
General Chemistry
Physics I
Basic Anatomy

Semester (2)
Arabic Language
Scientific English
Descriptive Geometry
Introduction to Computer System
Physiology
Organic Chemistry
Physics II
Engineering Math II

Second Year Semester (3)
Introduction to Computer System -II
Scientific English – III

Engineering Math – III
Cellular Biochemistry
Engineering Mechanics
Circuit Theory I
Analogue – I

Semester (4)
Introduction to Computer System -II
Scientific English – IV
Engineering Math – IV
Bio Materials
Fracture Mechanics
Circuit theory II
Analogue – II
Biomedical Physics

Third Year Semester (5)
Engineering Math – V
Biomechanics & Biofluids
Heat and mass transfer
Electronical and Electronics Measurements
Electromagnetic fields
Digital Electronic –I
Electrical Machines

Semester (6)
Digital Electronic –II
An Introduction to Radiation physics and technology I
Numerical Methods
Power Electronics
Hospital Engineering
Assembly Language
Communication Technology

Fourth Year Semester (7)
Data net working
Interfacing

An Introduction to Radiation physics and technology II
Bioinstrumentation and biosensors –I
Probability & Biomedical Statistics
Control Theory & Systems
Micro-processors – I
Engineering Management

Semester (8)
Digital signal processing
Bioinstrumentation and biosensors – II
Micro Processors – II
Medical Imaging Measurements and Safety
Biological System Modeling
Engineering Economics
Rehabilitation Engineering

Fifth Year Semester (9)
Digital Image Processing
Artificial Organs and Tissue Engineering
Nuclear Medicine –I
Quality Assurance & Reliability
Research Methodology

Semester (10)
Medical Ultrasound
Nuclear Medicine –II
MRI
Computer Tomography
Optoelectronics & Lasers
Electrosurgical Devices
Prosthetic and artificial organs
Clinical laboratories
Hospital Information Systems
Computer Based Patient Record
Computer Network Health care
Neural Network & Artificial Intelligence
Biocybernetics

The information in this paper is relevant to 2006.

Statistical Information (Wikipaedia, 2009; IMF, 2008; IOMP, 2009)
Republic of the Sudan

Population estimate, 2009	42,272,000
GDP per capita, 2008	US$1,522
Medical Physicists in Society, 2009	11

Medical Physics in Ghana

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Medical Physics / Biomedical Engineering Education and Training

The School of Allied Health Sciences, College of Health Sciences of the University of Ghana (UG) began training Medical Physicists in 2004. Before this the Medical Physicists in Ghana were trained abroad. The first batch of six students was admitted to pursue the M.Phil degree in Medical Physics. The programme prepares graduates for careers in hospitals (clinical practice), industry, universities and research institutions. The course modules are oriented to medical application, particularly relevant to hospital physicists, and encompass all aspects of the application of the physical sciences to medicine. The duration of the programme is two years with a minimum of 60 credits. The first year consists of theoretical lectures. The second years is devoted to clinical training, individual research projects, seminar presentations and preparation of a thesis. This is followed by one year internship at the hospital covering diagnostic radiology, nuclear medicine and radiotherapy.

The entry requirement for the programme is a First Degree in Physics (or equivalent). However, applicants with qualifications in appropriate areas of applied science as well as those with other qualifications together with suitable practical experience may also be considered. The programme of study provides the essential academic component for the professional training of medical physicists (as established by a professional body like the Institute of Physics and Engineering in Medicine - IPEM). The syllabus is planned to be revised regularly, based on the requirements of IPEM and the International Atomic

Energy Agency (IAEA). Possible areas of employment for successful graduates include hospitals, industries, research institutions and the academia among others. It is expected that graduates will contribute to improved diagnosis and treatment, the development of safe practices and procedures and the provision of quality assurance services in the country and Africa.

Currently, the first class of the programme has graduated successfully from the University of Ghana as the first group of locally trained Medical Physicists. The second group of five trainees has completed their studies (and await graduation) and the third group of three has submitted their thesis for assessment. At the moment, the fourth group of four is in their second year of the programme. This is under the auspices of a Post-Graduate School of Nuclear and Allied Sciences (SNAS), established jointly by the Ghana Atomic Energy Commission and University of Ghana, in co-operation with the IAEA. The SNAS has been designated by the IAEA as African Regional Cooperation Agreement (AFRA) for Nuclear Science and Technology Centre to train engineers and scientists from neighbouring countries and the sub-region. Several Master of Philosophy Programmes of the school have been accredited and Doctor of Philosophy Programmes (including Medical Physics) has also been delivered. It is expected that the establishment of SNAS will assist in the preservation of the nuclear physics knowledge in Ghana and Africa.

For biomedical engineering training, two public institutions namely, the Kwame Nkrumah of Science and Technology and the University of Ghana started with the training of the necessary personnel required by the health sector at the Undergraduate Level, for three/four year programme. However, some private universities have also been granted accreditation to run the programme.

Status of profession

In Ghana, there are about thirty Medical Physicists / Engineers who can be found in hospitals, industry, research institutions and the academia. There are two radiotherapy centres in Ghana and the role of the medical physicist (especially in the radiotherapy centres) is very critical. They are charged with the following responsibilities:

- specification of equipment
- acceptance testing, commissioning and calibration of equipment
- analysis of beam data
- tabulation of beam data
- establishment of dose calculation procedures
- establishment of treatment planning procedures
- supervision of equipment maintenance
- yearly review of policy and procedure manual
- radiation safety

Medical physicists in research institutions and academia are also engaged in research in medical health physics, diagnostic radiology, nuclear medicine and radiotherapy. Unfortunately, the roles of medical physicists in diagnostic radiology departments have received very little attention, what endangers the accurate diagnosis and patient protection. It is however expected that they will take charge of issues of quality assurance, dosimetry, as well as radiation protection, safety and security in the near future.

In another development, SNAS has put in place an Executive Committee and Task Force to draw out the necessary modalities for the establishment of Ghana Society for Medical Physics and streamline their Education and Training (as Medical physics experts are identified as one of the professional groups for whom training is mandatory). The following tasks are assigned:

1. Make a critical assessment of the standard of medical physics practised at the nation's Military Hospital which has professionally recognized Medical Physics and make recommendations for the improvement in the services.
2. Come out with pragmatic means by which these services could be extended to all hospitals in the country with diagnostic facilities.
3. Identify equipment needed for the implementation of the IAEA Technical Report Series No. 457 on Dosimetry in Diagnostic Radiology: An International Code of Practice and seek support

from the stakeholders in health delivery for the procurement of the equipment

4. Plan training courses on the implementation of the IAEA Code of Practice
5. Identify international experts needed for the training courses and other activities bordering on the implementation of the Code of Practice.
6. Source funds through the various AFRA and IAEA Technical Cooperation (TC) projects to support the invitation of the experts
7. Liaise with all relevant stakeholders to discuss job placement and conditions of service for medical physicists and work towards the recognition of medical physics as a profession.
8. Carry out other activities to enhance the efficient and safe delivery of radiation for diagnostic and therapeutic purposes

At the end of this exercise, it is expected that Medical Physics Education and Training will capture the following four key important elements:
(i) well-defined entry criteria-a good degree in physics (or equivalent) from a recognised university; (ii) postgraduate education in medical physics (didactic + research); (iii) practical training (clinical training in hospital); and (iv) examination and certification. (to obtain a license renewable by an Accreditation Board).

Continuous Professional Development of Medical Physicists will be required because the Medical Physics Expert or Consultant (either in radiotherapy, nuclear medicine and diagnostic radiology) may be required to advise as well as act during practice. This will ensure that the career path for Medical Physicists training and practice is streamlined to be in line with International best practice. This will make Medical Physicists to respond adequately to challenges, especially harmonisation of standards of practice and keeping abreast with technological developments.

New professional development at present

On professional development, Ghana is involved in some IAEA Technical and Research Projects. Ghana's Technical Cooperation programme with the Agency has covered topics ranging from isotope hydrology and industrial applications of nuclear technology to nuclear medicine and radiotherapy. Some individuals have also been beneficiaries of numerous training courses. Some have also served on IAEA expert missions.

The following are some of the IAEA Projects that the Country is currently participating in:

- RAF/6/031 - Medical Physics in Support of Cancer Management.
- RAF/9/027 - National Regulatory Control and Occupational Radiation Protection Programmes.
- RAF/9/028 - Post-Graduate Training in Radiation and Waste Safety.
- RAF/9/029 - Development of Technical Capabilities for Sustainable Radiation and Waste Safety.
- RAF/9/031 - Strengthening National Regulatory Infrastructure for the Control of Radiation Sources.
- RAF/9/032 - Development of Technical Capabilities for the Protection of Health and Safety of Workers Exposed to Ionizing Radiation.
- RAF/9/033 - Strengthening Radiological Protection of Patients and Medical Exposure Control.
- RAF/9/034 - Establishment of National Capabilities for Response to a Radiological and Nuclear Emergency.
- RAF/9/035 - Education and Training in Support of Radiation Protection Infrastructure.

The objectives of the project RAF/9/033 cover seven tasks, namely:

1. Avoidance of radiation injuries in interventional procedures using X-rays, and limiting probability of stochastic effects, especially in children.
2. Surveys of image quality and patient doses in simple radiographic examinations; establishing guidance levels and comparison with international standards.
3. Exercising dose reduction in conventional radiography by using rare earth intensifying screens.

4. Survey of mammography practice from the optimization of radiation protection view point.
5. Patient dose management in computed tomography with special emphasis to paediatric patients.
6. Providing guidelines on the release of patients after radionuclide therapy based on current recommendations of ICRP.
7. Taking steps to avoiding accidental exposure in radiotherapy.

Out of these seven tasks, Ghana is participating in tasks 2, 4, 5 and 7.

And for RAF/6/031 project, its objectives are:

1. To increase the number of medical physicists in the region through academic education and training programs.
2. Promote recognition of the profession of medical physics.
3. Promote regional cooperation in the field of medical physics (International Organization of Medical Physicist, Regional Designated Centres).
4. To support and/or upgrade the establishment of implementation of medical physics quality assurance programs including the traceability of the calibration of equipment to the international measurement system.
5. To support maintenance management programs.

There are also plans by the government of Ghana to upgrade and expand Radiotherapy and Nuclear Medicine Services under the national project GHA/6/015. Under this project, the existing facilities at the Oncology Centres in the Southern part of the Country will be upgraded and a third Centre established in the Northern part of the Country. Another National Project-Establishment of Nuclear and Medical Imaging Centre is also underway which is expected to benefit from the action plan of the Programme of Action for Cancer Therapy (PACT). PACT will provide training of more Radiation Oncologists, Nuclear Medicine Physicians, Medical Physicists, etc.

Prediction for the needs of new medical physicists / engineers

In the next 10-15 years, about 100 Medical Physicists / Engineers are expected to be trained. It is also expected that Medical Physics Departments would be established in our hospitals in order to provide employment for Medical Physicists and give more recognition and relevance to the profession. The Education and Training, Examination and Certification as well as Continuous Professional Developments of Physicists will be streamlined.

Statistical Information (Wikipaedia, 2010; IMF, 2010; IOMP, 2009)

Republic of Ghana

Population estimate, 2010	24,000,000
GDP per capita, 2010	US$762
Medical Physicists in Society, 2009	28

EMERALD and EMIT e-Learning Materials for Medical Physics Training

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EMERALD and EMIT Consortia (www.emerald2.eu)

The effective teaching in Medical Physics requires numerous specific materials (images, diagrams, simulations and specific explanations). These requirements provide an excellent background for application of e-Learning. During the last decade the EU projects Consortia EMERALD and EMIT developed 5 volumes of such materials. EMERALD developed e-Learning materials in 3 areas of Medical Physics (X-ray Diagnostic Radiology, Nuclear Medicine and Radiotherapy). EMIT developed e-Learning materials in 2 further areas - Ultrasound and Magnetic Resonance Imaging.

The concept of the EMERALD and EMIT e-Learning materials was based on development of skills and competencies through practical performance of specific tasks. Each training module includes a number of prescribed tasks, which gradually build the necessary competencies. Initially the Consortia aimed at development of materials to support the training of medical physicists, however with time these materials found stable place in the university medical physics teaching.

The length of each module was carefully selected. Each task within each of the modules was given a notional completion time (of the order of 1-2 days) and the total for each module was 80 days (i.e. 4 months).
Each of the 5 Training Modules incorporates:
-List of Competencies (in accord with UK's IPEM Training scheme);
-Structured Timetable (detailed curriculum, available at web site www.emerald2.eu);
- Student Workbook with tasks (e-books);
- Image database

Each task in the Workbooks is described using a standard format. It contains explanations and protocols to be followed and requires answers to specific questions and problems. The tasks are designed to methodologically build-up various skills and competencies. The number of tasks are as follows: X-ray Diagnostic Radiology – 50; Nuclear Medicine – 46; Radiotherapy – 48; Magnetic Resonance Imaging – 50; Ultrasound Imaging – 54.

The EMERALD and EMIT e-Learning materials have been prepared with the intention of using them internationally. To achieve consistency of use the programmes include a Course Guide with instructions for the supervisor.

These materials consist of e-books and educational image databases (IDB). The five e-books include tasks supporting the study of various equipment and methods. The text of these PDF e-books is hyperlinked with respective images. The e-books are used through the readers' own software. This simplicity allows for the user to learn directly through his/her existing computer and its Internet browser and Adobe Acrobat Reader.

An overall hyperlink structure of all tasks (through the training timetables) holds all training entries together. In this structure the tasks in each module are grouped in chapters, according to the logical built-up of knowledge. The first chapters are related to the "building elements" (explanation of equipment, particular measurements and other details); the following tasks combine these "building elements" into various "protocols" (related to specific equipment). These tasks are now also used in various Universities as laboratory practical tasks.

The use of these e-Learning materials requires simultaneous work with two browser windows (main and image windows). The main window includes a large text frame for the PDF file; a contents frame for navigation through the training tasks; and a thumbs frame for browsing the images. The additional image window contains the respective image (hyperlinked to the text) and image caption. The images are in

JPG format, embedded in HTML frames. All functionality of Adobe Acrobat Reader is preserved, allowing saving and printing of each part of the e-learning materials.

EMERALD and EMIT e-Learning materials can be used either through the Internet, or from CD-ROMs (where the Web site is engraved together with the educational Image database). From this point of view the materials are ready for network use. The intuitive interface of EMERALD and EMIT e-Learning materials allows immediate use of the materials without any „learning curve“ (the only knowledge required is that for use of an Internet Browser).

The five IDB include hundreds of images of equipment; block diagrams and graphs; QA procedures and test objects; image quality examples; artefacts, etc. Both the e-books and IDB are engraved on 5 separate CD-ROMs. All IDB use own Image Browser (which also includes image processing capabilities). In order to facilitate the training, the organization and numbering of the image directories (within each IDB) follows the numbering of the chapters in the e-Workbooks with tasks.

To assess the usability of these the Consortia organised two International Conferences on Medical Physics Training with e-Learning materials (1998 and 2003, ICTP, Trieste, Italy) and 5 international Seminars. These conferences attracted specialists from 26 countries (including IOMP) and resulted in very useful comments on application of e-Learning materials for teaching Medical Physics. Based on these the International Medical Physics College at ICTP uses e-Learning in many of its lectures and practical sessions.

By now the EMERALD and EMIT e-Learning materials are used in approx. 70 countries. To facilitate the international use of these e-Learning materials a special multilingual Dictionary of Medical Physics Term was made (cross translating between 9 languages at the moment). This tool is available at the web address: www.emitdictionary.co.uk (now merged with EMITEL e-Encyclopaedia at www.emitel2.eu) .

The innovative contents of the training pack, made these Medical Physics training materials a widely used e-learning tool. In 2004 the European Union awarded the project Consortia with its highest prize for education – the Leonardo da Vinci Award. More info about these projects and a fully working demo can be taken from www.emerald2.eu

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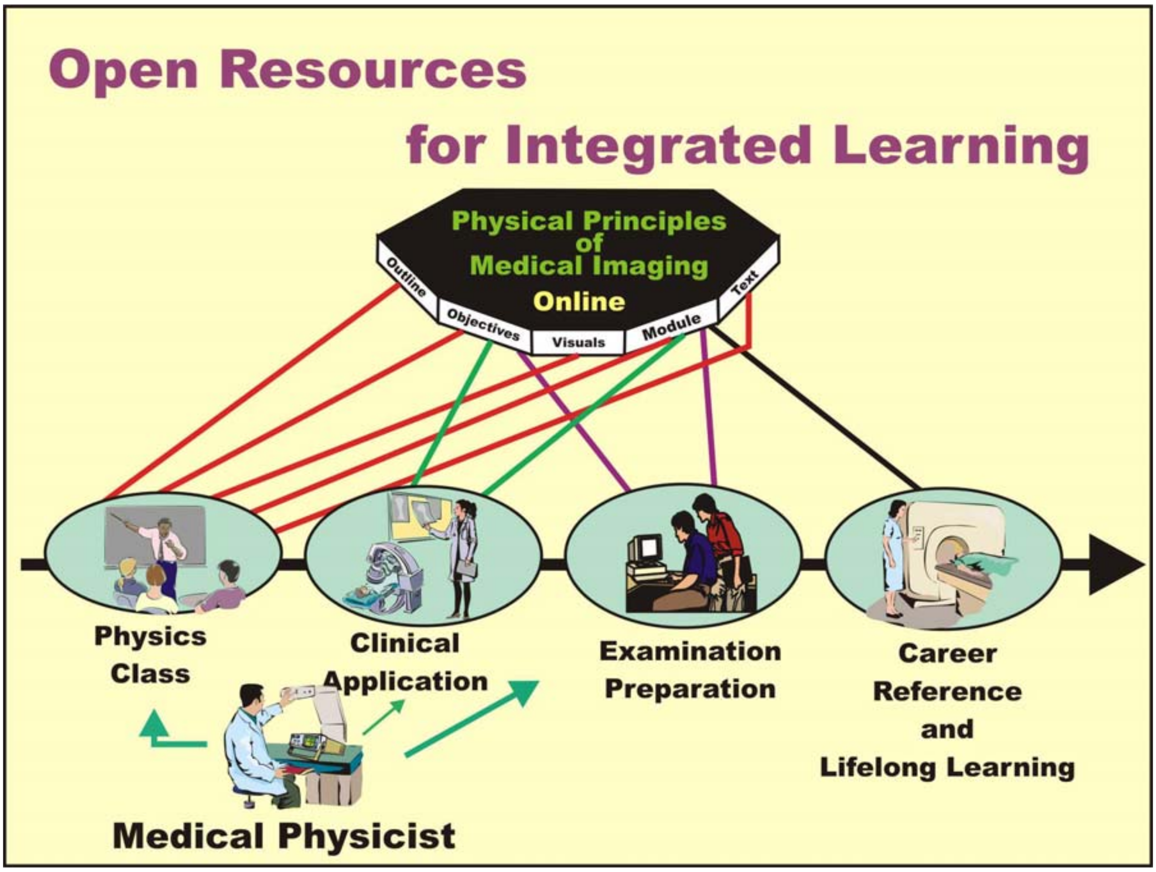
Delegates to the International Conference on Medical Physics Training with e-Learning materials at ICTP, Trieste, Italy (10-11 October 2003), including EMERALD and EMIT Consortia members

The Physical Principles of Medical Imaging Online
An Open Resource for Integrated Learning
http://www.sprawls.org/resources

Perry Sprawls, Ph.D. (sprawls@emory.edu)
Sprawls Educational Foundation, NC, USA



Introduction and Overview

The learning of the physics and technology of medical imaging is a multiple phase process. It generally begins with classes within academic programs and continues to include applied experience in the clinical environment, study and review for examinations, and continuous learning throughout a career.

The Physical Principles of Medical Physics Online (PPMPO) is designed as a resource to support each of these phases of learning. Its objective is to enhance the performance of learners (students), learning facilitators (teachers), and the medical imaging professionals (medical physicists, engineers, physicians, and technologists) in the application of physical principles and a knowledge of the technology to effective and safe medical imaging.

It is a supporting resource for multiple teaching and learning methods including: classroom lectures, small-group collaborative learning, problem solving, laboratory and practical applications, continuing education and life-long learning, and as a general reference during various educational and clinical activities.

Resource Components
The PPMPO is a multi-faceted resource with components that are combined to support each of the learning phases. The specific components are:

- A Model Curriculum
- Topical Outlines
- Learning Objectives and Activities
- Visuals for Classroom and Conference Discussions
- Topical Modules for Individual Study and Reference
- Online Textbook

Classroom Learning and Teaching
The classroom provided an introduction to physics and technology in a generally organized structure. Several of the components support these classroom activities. The model curriculum can be adopted or modified to fit within a specific institutional academic program. All of the components can be used in the context of classroom teaching as determined by the on-site medical physics faculty.

Classroom lectures and discussions by on-site medical physics faculty are enhanced with the use of the visuals designed to enrich the learning environment. This fulfills one of the major needs leading to effective teaching. Visuals provide a window from the classroom into the world of physics and technology through which the faculty can guide the learning process and enrich it with personal experience and knowledge.

Laboratory and Clinical Applications
The direct application of physical principles and interactions with technology are essential to the development of knowledge that will support clinical imaging.

This occurs during structured laboratory investigations, simulations, and guided activities in the clinical environment. These activities can be guided by the Learning Objectives and Activities and used as an opportunity to review, reinforce, and apply concepts learned in the classroom and through self study.

The online modules are used during this phase as a reference and to integrate the various learning activities.

Review and Preparation for Examinations
It is assumed that the examinations evaluate competence in the general knowledge of medical physics and the application of this knowledge to applied clinical imaging. Therefore, the Learning Objectives and Activities and the Self-study Modules are useful for reviewing and preparing for examinations.

Continuing Education and Lifelong Learning
Continuing education and lifelong learning is critical to the application of physical principles to medical imaging because of rapid developments in imaging methods and technology. The fact that online modules can be quickly updated makes them appropriate resources for continuing education.

Documented continuing education is often required for maintaining professional credentials. Since the Learning Objectives and Activities and the Self-study Modules are open resources they are available to organizations for incorporation into accredited programs for testing and awarding credits.

Career Reference
The PPMPO is an open resource and readily available online throughout the world. Therefore it is a useful reference for

professionals throughout their careers. It is of special value to educators and a source of information on specific topics to those in clinical practice.

Summary

The ***Physical Principles of Medical Imaging Online*** http://www.sprawls.org/resources is being developed as a multi-faceted open resource to support the effective teaching and learning of the concepts and applications of medical physics and the optimum and safe use of imaging technology.

Training in Medical Radiation Protection- the IAEA's actions

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The main purpose of training in radiation protection is to make a qualitative change in practice that helps operators use radiation protection principles, tools and techniques to reduce one's own exposure without cutting down on work and to reduce patient's exposure without compromising on image quality or intended clinical purpose.

A key component in the success of any training programme is that the material must be relevant and presented in a manner that medical professionals can relate to their own situation.

The trainer in radiation protection should have the knowledge of practicalities. Since radiation protection is normally covered under regulations in almost all countries of the world, the awareness about national regulations, responsibilities of individuals and organizations acquire a place in training.

A training programme in radiological protection (RP) for healthcare professionals has to be oriented towards the type of practice the target audience is involved. There are currently successful examples of training, in particular, from International Atomic Energy Agency [1]. The key features of the IAEA training programs in radiation protection have been:

1. Narrowing the target groups
2. Preparing standardized training material and making it available to lecturers
3. Instead of assuming that training programs will bring qualitative change in practice, organizing training programs to meet the

needs of practice and projects with feedback through results and thus achieving accountability
4. Using the website (http://rpop.iaea.org) to enhance dissemination
5. Making training material available free as power point slides (rather than pdf files)
6. Extending the training to cover un-conventional target groups

A brief description of each point follows.

1. *Narrowing the target groups*: In 1990's the training programs would include in audience those whose interest in deliberations in the program may be small percent of whole program. If there is a training program on radiation protection in medicine, those who are full time working in diagnostic radiology will not have interest in lectures pertaining to radiotherapy, nuclear medicine etc. Thus we designed program such that there is 100% relevance of topics in training to each person.

2. *Preparing standardized training material and making it available to lecturers*: The IAEA conducts large number of training courses all over the world and utilizes services of large number of experts/lecturers for its training courses. Therefore the policy was developed to have standardized training curriculum and material and make it available to lecturers in its training courses. The material have been developed on Radiation Protection in a) Diagnostic and interventional radiology, b) Radiotherapy, c) Nuclear Medicine, d) Prevention of accidental exposures in radiotherapy, e) Cardiology, f) PET/CT and g) Paediatric radiology.

3. *Organizing training programs to meet the needs of practice and projects*: Initially the training programs were mainly conducted on thematic areas, as above, for which material was developed. The utility of such training courses was limited and it was difficult to ascertain if this is bringing a change in practice for achieving radiation protection. In 2005 the training programs were tailored to meet the needs of the IAEA technical cooperation (TC) projects on radiation protection of patients and protection in medical exposure.

These projects required developing skills in patient dosimetry and accordingly the training actions were tailored to achieve the objective. Since the participants in these courses were those who were involved in project, the results submitted against the project provided the value of experience gained. A number of publications have emerged as a result of this approach [2-6]

4. *Using the website to enhance dissemination*: In view of limited outreach of the traditional training courses, and the fact that nearly 4 billion diagnostic radiological examinations are performed the world over, with involvement of few millions of health professionals, it was deemed appropriate to develop a dedicated website http://rpop.iaea.org. The website provides short but meaningful answers to highly selectively framed question with great relevance to practice. A large number of areas are covered on the website e.g. under health professionals: radiology (standards, radiography, mammography, digital radiography, computed tomography, fluoroscopy), radiotherapy (standards, accident prevention, radiation safety in external beam therapy, brachytherapy and in endovascular brachytherapy) nuclear medicine (standards, diagnostic, therapeutic nuclear medicine and biomedical research), interventional radiology, interventional cardiology, other specialities and imaging modalities (PET/CT, dental radiology, DEXA, gastroenterology, orthopaedic surgery and urology). A significant part of the information pertains to patients. With these features and contents, this website has become a unique source of credible information. Even though the website is named radiation protection of patients, it covers significant aspects of staff protection in particular in interventional procedures, PET/CT and many other areas.

5. *Making training material available free as power point slides*: The policy of the IAEA is to make material available for wide use in the world. In keeping with this policy, power point slides rather than pdf files of training material are available for free download. These are available on Radiation Protection in a) Diagnostic and interventional radiology, b) Radiotherapy, c) Nuclear Medicine, d) Prevention of accidental exposures in radiotherapy, e) Cardiology, f) PET/CT and soon going to be made available on g) Paediatric radiology. Some

training material has been translated into Spanish and is also available for free download. The material is also available in CD which is provided on request and permission is granted to conference organizers and professional societies to make copies of the CDs and distribute it free to members.

6. *Extending the training to cover un-conventional target groups*: Realising that there are a number of clinical areas like cardiology and non-radiologist using fluoroscopy (orthopaedic surgeons, urologists, vascular surgeons, gastroenterologist, gynaecologists etc.), training programs were launched for cardiologists in 2004 and for non-radiologist using fluoroscopy in 2006. These training programs have created significant impact in practice and regional networks have been created. Such network and actions by such doctors are unique.

About a dozen regional training courses and a similar number of national training courses are organized each year on this subject. The RPOP website is receiving over a million hits per month through over 14,000 absolute unique visitors per month and training material pages receive the largest visits.

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A Hands-on Approach for Teaching Principles of Treatment Planning to Medical Physicists

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1. Introduction

Processes involved in treatment planning play a pivotal role in understanding concepts in radiation therapy. At the University of Canterbury in Christchurch, New Zealand, students in the Medical Physics MSc programme learn about the basic principles of treatment planning in formal radiation therapy lectures, which are based on the recommended textbook "Radiation Oncology Physics: A handbook for teachers and students", published by the IAEA. In addition to lectures, practical training sessions are indispensable to facilitate the learning process. It is against this background that a framework for a learning environment for radiation therapy treatment planning was developed based on a non-commercial open source treatment planning system (TPS). To allow independent work of the students a web based tutorial was designed and developed, guiding the students through various learning modules, including challenges and quizzes. The level of the tutorial is such that it builds on the knowledge from the lectures. It is important to note that the intention of the tutorial was not to provide a practical training in the operation of a treatment planning system but focuses on learning outcomes to enhance and expand the student's knowledge gained in the lectures.

2. Treatment Planning System

The tutorial is written with reference to the *Prism* treatment planning software[1,2], which has been developed at the University of Washington,

[1] Kalet I.J., Jacky J.P., Austin-Seymour M.M., Hummel S.M., Sullivan K.J. and Unger J.M., *Prism: a new approach to radiotherapy planning software*, Int J Radiat Oncol Biol Phys **36**:451-461, 1996.

Seattle, WA, USA. The *Prism* TPS offers several features, which are valuable for educational use. *Prism* is straightforward to use, possesses all main features of a modern TPS (i.e. full three dimensional capabilities) and is DICOM (Digital Imaging and Communications in Medicine standard) compatible. While the source-code and documentation of *Prism* are freely available for non-profit educational use, currently in order to run *Prism* an Allegro Common LISP[3] license has to be purchased. A one-off licence is available at relatively small cost and this is the only expense beside a PC. Note that we are investigating the use of *Prism* without requiring users to have fully-paid licenses for Allegro CL by creating an Allegro runtime application[4]. *Prism* runs on a Linux environment and the hardware requirements are low and lie well within the specifications of current standard PCs. The installation of *Prism* is well-documented[5] and straightforward.

Prism can be run and displayed locally on the Linux computer where it is installed, but it is also possible to redirect the display to another computer using an X terminal. This allows multiple users from remote PCs to simultaneously connect to *Prism* at the same time but each user can run an independent *Prism* session, which is redirected and displayed locally on the user's PC. At the University of Canterbury sessions with about 10 remote connections to the main PC have been conducted without any noticeable impact on the performance of individual sessions.

Another valuable *Prism* feature with regards to multiple tutorial users is that it contains a main database, accessible by all users, as well as a customizable local database for each individual user, as illustrated in

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2 University of Washington, *The Prism Radiation Treatment Planning Project*, [cited November 23, 2009], available from

http://www.radonc.washington.edu/medinfo/prism/**, 2009.**

3 *Allegro Common Lisp 8.q*, [cited March 6, 2009], available from http://www.franz.com/products/allegrocl/, 2009.

4 Allegro CL version 8.1, *Allegro CL Runtime*, [cited November 25, 2009], available from http://www.franz.com/support/documentation/8.1/doc/runtime.htm#runtime-intro-1

5 Kalet I.J., *SLIK Programmer's Guide, Version 2.1 (Technical Report)*, Radiation Oncology Department, University of Washington, Seattle, WA, USA, 2004.

Figure 1. This allows for easy maintenance and avoids that the main database becomes cluttered.

Prism comes with a fully functioning DICOM server, which makes the system compatible with other TPSs. Figure 1 also illustrates the Prism DICOM environment. The Prism DICOM server can receive DICOM CT images and DICOM RS structure sets and can export DICOM RTP treatment plans as are typically sent to a record and verify system or directly to a linear accelerator. Note that for the tutorial the same external DICOM server was used to send DICOM CT images and radiotherapy structure sets (RS) to *Prism* and to receive completed Radiotherapy Plans (RTP) from *Prism*, simulating the therapy machine.

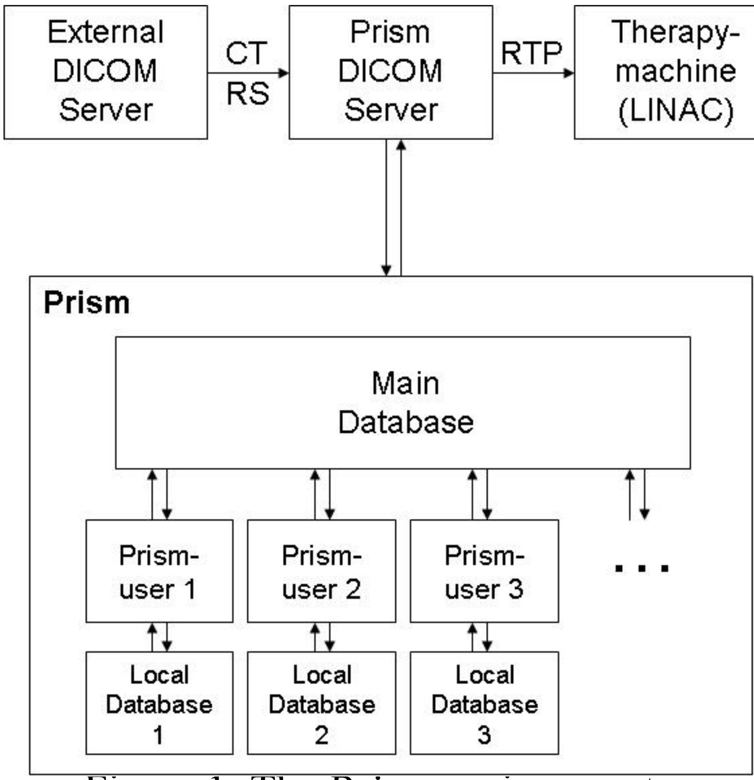

Figure 1: The *Prism* environment

The modular design of *Prism*, consisting of different panels, allows adding or changing data items in the treatment plan at any time rather than enforcing a sequence of operations. This makes the system flexible and avoids that students learn a particular sequence, as required for some commercial treatment planning system, but encourages them to consider (and therefore understand) each step in the planning process. The students are free to explore the *Prism* panels in any order.

Due to the modular design and the use of Lisp as programming language *Prism* is highly customizable and functionality can easily be added or changed. Several other programs, all of which are open-source helped to embed *Prism* in a well-operating environment. More details can be found elsewhere [6].

3. Tutorial

The scope of the tutorial was to cover all pertinent aspects of modern 3D treatment planning. Starting with the import of computed tomography (CT) data sets into *Prism*, the actual treatment planning procedures and finishing off with plan evaluation, the simulation of a DICOM transfer to a therapy machine and plan documentation. The students have the opportunity to familiarize themselves with all important aspects of the treatment planning process. The overall time frame of the tutorial is about nine hours. To reduce the workload into a more manageable timeframe the tutorial was split into three learning modules (see Figure 2). A web-based interactive design was chosen to allow independent work of the students. This is described in more detail in section 3.4.

3.1 Structure

Each of the learning modules reflects a certain structure consisting of four units, as illustrated in Figure 2 on the right hand side. In Unit 1 a brief overview of the learning objectives and the contents of the particular module are given, followed by the introduction of all *Prism* features required in the particular learning module. Unit 2 comprises the actual learning tasks, which introduce the individual steps in the treatment planning process. The challenge in Unit 3 enables the students to apply the knowledge they have gained in Unit 2 to slightly different situations. Together with Unit 4, which contains an interactive self-scoring multiple-choice quiz, these last two units give the students

[6] Meyer J., Hartmann B. and Kalet I.J., *A ‚learning-by-doing' treatment planning tutorial for medical physicists,* Australas Phys Eng Sci Med **32**(2):2009.

a means to check whether the learning objectives of the module have been achieved. After submitting the answers of the quiz, the students receive immediate feedback and get the chance to repeat the quiz until all questions are answered correctly.

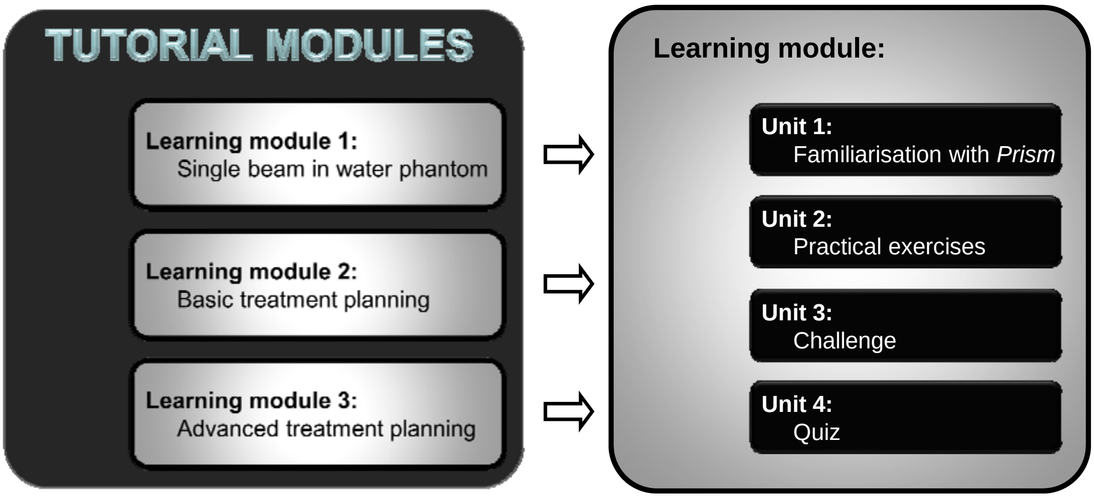

Figure 2: Structure of the tutorial (left) and each individual learning module (right)

3.2 Content

Learning module 1 introduces the students to elementary planning concepts and mainly deals with penetration characteristics of a single photon beam in a water phantom. After learning about basic operations of the treatment planning system, the effects of varying different photon beam parameters such as beam energy, beam size and source-to-surface distance on the dose distribution can be explored. The effects of wedges in the beam and inhomogeneity corrections are also investigated.

The second learning module requires the students to familiarize themselves with basic steps of the treatment planning process. The CT data set of the ESTRO Quasimodo phantom[7,8] is used for this task. After dealing with manual definitions of volumes of interest (VOIs) and automatic contour expansion the students create multileaf-

[7] Universitätsklinikum Würzburg. *Quasimodo-Patientenmodell*, [cited December 2, 2008], available from http://www.daten.strahlentherapie.uni-wuerzburg.de/quasimodo.html, 2009.
[8] Bohsung, J., Gillis, S., Arrans, R., Bakai, A., De Wagter, C., Knoeoes, T., Mijnheer, B.J., Paiusco, M., Perrin, B.A., Welleweerd, H. and Williams, P., *IMRT treatment planning – A comperative inter-system and inter-centre planning exercise of the ESTRO QUASIMODO group*, Radiother Oncol 76(3), 354-361, 2005.

collimator (MLC) based beams and adjust them to the target volume in the beam's-eye-view (BEV). Isocentric plans with 1-3 fields, with and without wedges are generated and manual adjustment of beam weights and plan normalization are practiced to get a feel for the intricacies of treatment planning. The challenge consists of creating a 5-field plan for the given phantom case. The students can also explore conformal arc therapy and an automatic beam angle optimization tool[9].

Learning module 3 deals with advanced treatment planning skills such as evaluation and comparison of different treatment plans by means of dose statistics, dose volume histograms (DVHs) and biological models (normal tissue complication compatibility (NTCP) and tumour control compatibility (TCP)). The final challenge is to create a suitable treatment plan for a clinical case meeting clinical specifications and constraints. Therefore the students can select from a range of clinical cases which have been contoured by clinicians. Finally, the plan transfer to the therapy machine is simulated and the students produce appropriate documentation of their plans.

The tutorial concludes with a short survey providing the students with the opportunity to give feedback and comments on the tutorial and their learning experiences.

3.3 Learning methodology

The philosophy behind the tutorial is 'hands-on' and 'learning-by-doing', meaning the approach to learn computerized treatment planning while doing practical work with the *Prism* TPS. This gives the students the chance to link objects with ideas and thus enhance their theoretical knowledge gained in lectures on treatment planning in a series of practical sessions. The students can acquire a sound understanding of the complex matter and develop a feel for intricacies. As a computer-mediated component of a blended learning course, meaning the combination of face-to-face lectures (the radiation therapy classes) and a computer-based learning part (the tutorial), the tutorial enables the

[9] Meyer J., Hummel S.M., Cho P.S. et al., *Automatic selection of non-coplanar beam directions for three-dimensional conformal radiotherapy*, Br J Radiol 78(928):316-27, 2005.

students to experience a different way of learning that is self-directed rather than instructor-driven[10].

The web-based layout of the tutorial allows the students to work independently. This enables them to work whenever and wherever they want, with the only instrument needed being a computer with network access. Each student can work without time pressure and decide individually how much time to spend on which topic. This means the students can control content and pace of their learning themselves and there is no pressure to perform. With the use of interactive design features it was managed to integrate different tools to provide feedback and give the opportunity to monitor learning outcomes in the tutorial. In addition to the already mentioned self-scoring multiple choice quizzes, sample solutions are provided for the main tasks to give the students guidance and an idea whether they are going in the right direction. There are no solutions provided for the challenges, since there are often many solutions of equal validity. However, the challenges are posed in a way that makes the objectives and thus the success obvious to the students.

For the lecturer to monitor the learning outcomes templates are made available through hyperlinks in the tutorial. The students simply paste screenshots of their work into the template and hence submit a report to the course coordinator so that feedback can be provided. The use of templates also makes it easier for the lecturer to analyse and compare the work of the students. A Wiki is also available on the local intranet to support the students' learning. It allows the students to report errors, record 'tips & tricks' as well as any other comments or feedback and it is an ideal platform for an exchange of experiences between the students.

3.4 Implementation

The tutorial web-pages were created in *html* with the help of the composer included in the open source internet suite *Mozilla*

[10] Donnelly R. and McSweeney F., *Applied E-Learning and E-Teaching in Higher Education*, 1st ed., Information Science Publishing, Hershey, PA, USA, 2008.

SeaMonkey[11]. The students can work independently and are guided through the tutorial by familiar 'previous page' and 'next page' buttons. A screenshot of the tutorial implementation is shown in Figure 3. An explorer bar on the left side indicates all learning modules and units. The active unit is highlighted to show where the student is currently working. The explorer bar also allows the student to access particular units quickly. On the right hand side a second explorer bar provides links to additional pages, such as a summary of the general control functions of *Prism* or the *Prism* User's reference manual.

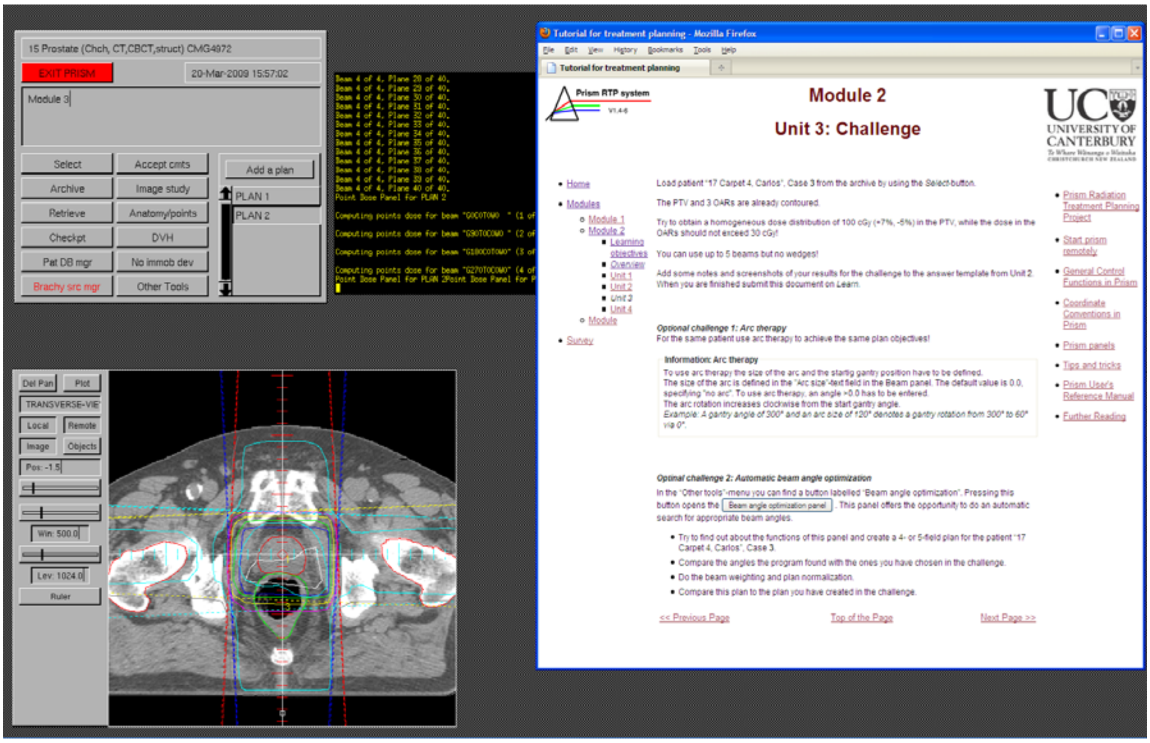

Figure 3: The tutorial (right) and several *Prism* windows displayed simultaneously.

The amount of information required depends on the skills and previous knowledge of the student. Thus throughout the tutorial illustrations and additional hints are available by means of pop-up windows accessible through hyperlinks or buttons. The idea behind this is to have the basic information to be able to complete the tutorial directly visible but to provide additional information if required. This keeps the reading task at a minimum and avoids that the students become fatigue and lose

[11] Mozilla Foundation. *The SeaMonkey® Project, Version 1.1.12.*, [cited March 3, 2009], available from http://www.seamonkey-project.org/, 2009.

interest. The interactive design also allows the students to check their learning progress with the above mentioned quizzes. These quizzes were also generated with open source tools[12].

It is noted that the Prism layout is such that it allows the user to arrange the windows at his/her convenience. Therefore it is possible to display the tutorial and the *Prism* windows simultaneously as shown in Figure 3. A dual monitor arrangement improves the desktop space but is not essential.

Conclusions

A framework for a learning environment has been presented consisting of the *Prism* treatment planning system and a web-based tutorial in treatment planning[13]. The *Prism* system lends itself well for learning purposes. The fact that it is straightforward to use, open source, customizable, comes with a DICOM server and can be remotely accessed by multiple users makes it ideally suited for a tutorial in treatment planning and the learning of the processes involved. The web-based design of the tutorial allows independent work of the students with continuous feedback. The web-based layout enables interactive features, contributing to an appealing learning environment. All main aspects of treatment planning are covered within the three existing learning modules. Nevertheless it is possible to add additional modules in the familiar structure with the possibility to include further aspects of modern treatment planning such as Brachytherapy planning, electron beam planning or intensity-modulated radiation therapy (IMRT).

Both the tutorial and the *Prism* implementation can be made available for interested parties upon request to the authors.

[12] Jordan, D.K. *Making On-Line Quizzes*, [cited February 25, 2009], available from http://anthro.ucsd.edu/~dkjordan/resources/quizzes/quizzes.html, 2009.
[13] University of Canterbury. *A self-guided tutorial for treatment planning in radiation therapy* [cited November 23, 2009], available at http://www2.phys.canterbury.ac.nz/~physmed/prismtutorial/Mainpage.html, 2009.

EMITEL e-Encyclopaedia of Medical Physics with Multilingual Dictionary

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I. INTRODUCTION

The field of medical physics and related technologies develops rapidly. The last 20 years introduced revolutionary methods such as Computed Tomography, Magnetic Resonance, Molecular Imaging, etc. All these enter quickly in healthcare and often limited information is available about these new methods and respective technology.

Our two previous projects EMERALD and EMIT [1] developed training materials (e-books and Image Databases) to address the initial training of young medical physicists. These included specific training tasks covering the physics fields of: X-ray Diagnostic Radiology, Nuclear Medicine; Radiotherapy, Ultrasound Imaging, MR Imaging. These materials are now used in more than 60 countries around the world (EMIT project received the inaugural Award for education of the European Union – the Leonardo da Vinci Award at Maastricht, 2004).

Both EMERALD and EMIT held Conferences, which revealed the need of a free professional reference source, linked to a multilingual dictionary of terms. This web tool was expected to quickly provide information for new, existing and old methods and equipment in Medical Physics. The tool was specially made to support the education, training and CPD process in the profession.

II. EMITEL PROJECT

The initial idea for this project was developed during the period 2001-2005 and was further prepared for submission to EU. At this stage the project partnership included the core of the previous project partners - King's College Lon-don (Contractor) and King's College Hospital, University of Lund and Lund University Hospital, University of Florence, AM Studio Plovdiv and the International Organization for Medical Physics (IOMP). This was the first EU project of IOMP as an Institution and paved its way for further inter-national projects and funding.

The objective of the new pilot project EMITEL (European Medical Imaging Technology e-Encyclopaedia for Lifelong Learning) was to develop an original e-learning tool, which will be used for lifelong learning of a wide spectrum of specialists in Medical Physics. Additionally to the e-Encyclopaedia a Multilingual Digital Dictionary of Terms was to be developed, to cross-translate the terms in any of its languages.

Medical Imaging was specially underlined in the name of the project, as this technology expands rapidly. However Radiotherapy and Radiation Protection were also included, together with a number of General terms associated with Medical Physics.

EMITEL project was funded by the EU programme Leonardo da Vinci, as well as by the project partners. The EMITEL Consortium has an agreement to continue its function after the end of the project, assuring a constant support and update of the project results

III. EMITEL DICTIONARY

EMITEL Dictionary used as a base the previous EMIT Dictionary (available from: www.emitdictionary.co.uk). The list of Medical Physics terms in this early Dictionary was further refined and expanded. Currently some 3500 terms are included. These terms were translated into 26 languages by colleagues listed at the end of this paper. Thus the original 7 languages English, Swedish, Italian, French, German, Portuguese, Spanish, were supplemented by new 19 languages: Bulgarian, Czech, Estonian, Greek, Hungarian, Latvian, Lithuanian, Polish, Romanian, Slovenian, Bengal, Chinese, Croatian, Iranian, Arabic, Malaysian, Russian, Thai, Turkish.

The Medical Physics Dictionary uses synchronized lists of terms, allowing cross-translation of terms between each two of its languages. The Dictionary database is expandable and can include additional languages (currently colleagues from Finland and India are considering the inclusion of their languages). The Dictionary was immediately popular and currently it has more than 2000 users per month.

The Dictionary was coordinated by S Tabakov and its software was made by AM Studio. EMITEL Consortium extends special gratitude to all Dictionary translators, who made this task free of charge. It is expected that the Dictionary will be of great help especially in the developing countries, where limited professional literature is available in the specific languages.

IV. EMITEL ENCYCLOPAEDIA

Each term from the Dictionary includes an explanatory article (entry) in English. The entries aim at MSc-level and above. Their volume varies in average from 50 to 500 words. The model of the Encyclopaedia is built around a larger number of specific entries, rather than small number of multi-page articles, which allows for quick search and easy update. However most of the EMITEL entries include References and information about other Related entries in EMITEL, this way forming information strings.

Many of the entries include images, graphs, examples and other additional information. Very often this additional information is related to the images from the previous projects EMERALD and EMIT. The entries are grouped in 7 categories – Physics of: X-ray Diagnostic Radiology, Nuclear Medicine; Radiotherapy; Magnetic Resonance Imaging; Ultrasound Imaging; Radiation Protection; General terms. Each entry includes contribution from at least three specialists – author, referee and group coordinator.

An original EMITEL web site was built by AM Studio (see separate paper about it). The web site uses the ability of the current Internet browsers to operate with all languages and combines the Dictionary and the Encyclopaedia. This way each translated term comes with a hyperlink displaying the corresponding entry. A multilingual Search Engine works with all languages of the Dictionary.

The fast development of Medical Physics led to the existence of a number of acronyms and synonym terms. To deal with this problem a second Search Engine was added to the web site, which looks inside the full text of the entries (in English) and displays those entries, where a particular synonym is mentioned. Care was taken, where possible, to include various terms modifications and variations.

EMITEL web site (www.emitel2.eu) is hosted by a commercial company. Alongside the database of terms, it has an additional internal web site with Content Management System (CMS, also developed by AM Studio). The function of the CMS is to allow future editing of existing entries, adding new information, images and diagrams, etc. The CMS also allows for new terms to be added with their own entries. This way EMITEL will act as the professional wikipaedia of Medical Physics, with the difference that only accepted entries and text will be uploaded (i.e. with editorial control). It is expected that the content of EMITEL will additionally be printed on paper and commercialized.

V. EMITEL NETWORK

EMITEL is perhaps the largest International project in the profession. Currently it includes approximately 240 colleagues from 35 countries, half being the translators (all colleagues who contributed to EMITEL are listed at the end of this paper). To develop and maintain the large volume of information an International Network was created.

The Network was first discussed and agreed during the EMITEL International Conference on Medical Physics, held at ICTP, Trieste, 24-26 October 2008 (ICTP – The Abdus Salam International Centre for Theoretical Physics). The Conference was attended by colleagues from 22 countries. Following this ICTP was accepted as a silent partner in the project.

The Conference delegates (on the photo) included the IOMP President, Secretary General, Treasurer, Chair of ETC, Chair of AHC, IFMBE Secretary General, IUPESM Secretary General, EFOMP President-elect and many distinguished colleagues from Europe and the rest of the world.

The Network internal links are maintained through an administrator in KCL. It is expected that the number of Network members will increase, as in future colleagues who contribute new articles and materials to EMITEL will be additionally included. This way the Network will assure the future support and expansion of EMITEL Encyclopaedia and Dictionary as a web site free to use by all colleagues.

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AFTERWORD

A substantial part of this book was ready for print in 2006 when the EMITEL Encyclopaedia project started. To keep the tight deadlines for this huge Encyclopaedia+Dictionary project (which included all book Editors) we had to temporarily freeze the book. Immediately after completion of EMITEL the development of the book continued. Many of the papers were updated to reflect the changes during the period, but some remained as information from 2006. This will be updated in the future part II of this book. In it we shall publish new papers about the current development of education and training. Apart from continuing the papers from Asia, Europe and Africa, part II shall include more papers from America, as well as specific papers from the countries with most experience in the field. Part II will also include more papers related to Medical Engineering.

Very important news arrived after completion of the book – our professions were included in the International Standard Classification of Occupations (ISCO-08). This excellent achievement will result in the official recognition of medical physicists and medical engineers in many countries, where such recognition does not yet exist. This will lead to the development of new University programmes (both at postgraduate MSc level and at undergraduate BSc level) and of new training courses (at lower and higher level). This will be extremely important for the development of the profession as a future stand-alone entity and will be reflected in the book part II. In this connection I shall be grateful to colleagues who would send me information on the new developments of Medical Physics and Engineering Education and Training in their countries/projects at: slavik.tabakov@emerald2.co.uk

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