RAF/6/038

PROMOTING REGIONAL AND NATIONAL QUALITY ASSURANCE PROGRAMMES FOR MEDICAL PHYSICS IN NUCLEAR MEDICINE

RAF/6/044

STRENGTHENING MEDICAL PHYSICS IN SUPPORT OF CANCER MANAGEMENT - PHASE II

REPORT OF A TASK FORCE MEETING ON A REGIONAL POSTGRADUATE MEDICAL PHYSICS SYLLABUS FOR ACADEMIC PROGRAMMES

2013

Recommendations for Medical Physics Education in AFRA Member States

This document is endorsed by the Federation of African Medical Physics Organizations

FOREWORD

This document is the culmination of Task Force Meeting reports held under the regional African Radiotherapy Medical Physics (RAF 6/027, RAF 6/031 and RAF 6/044) and Nuclear Medicine Medical Physics (RAF 6/032 and RAF 6/038) projects. The meetings were tasked to develop harmonized approaches to the recognition and education of medical physicists in the region. This document presents the recommendations for harmonized postgraduate academic education of medical physicists in the region.

Several International Atomic Energy Agency (IAEA) publications have been developed recently to support the education of medical physicists including the Technical Course Series 37, 47 and 50, which provide guidelines for the clinical training of medical physicists specialising in Radiation Oncology, Diagnostic Radiology and Nuclear Medicine, respectively. This series has three companion Handbooks and in addition, a syllabus for postgraduate academic education of medical physicists is in preparation. Member States are encouraged to adapt these documents to their national situation when establishing programmes.

The lack of recognition of the medical physics profession is a challenge internationally and an IAEA inter-regional project (INT6/054) produced a publication on the Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists in an attempt to promote the profession internationally.

Additional regional African task force meetings are being organised to develop guidelines for harmonized clinical training programs, and the companion logbooks that are needed to document the competencies acquired by a clinically qualified medical physicist. The document was endorsement by the Federation of African Medical Physics Organizations (FAMPO).

TABLE OF CONTENTS

1. INTRODUCTION

The aim of a postgraduate medical physics academic programme is to introduce students to the basic principles in all disciplines of medical physics in order to prepare them for a clinical training programme (hospital-based). Successful completion of the academic programme therefore leads to partial fulfilment of the requirements to be recognized as a clinically qualified medical physicist (CQMP). Fig. 1 schematically shows the recommended education requirements for recognition as a CQMP. Alternatively, the academic programme would prepare a student for an academic career in medical physics research or industry. The component circled in red is dealt with in this document and the regionally harmonized clinical training programme will be the subject of in future meetings and publications.

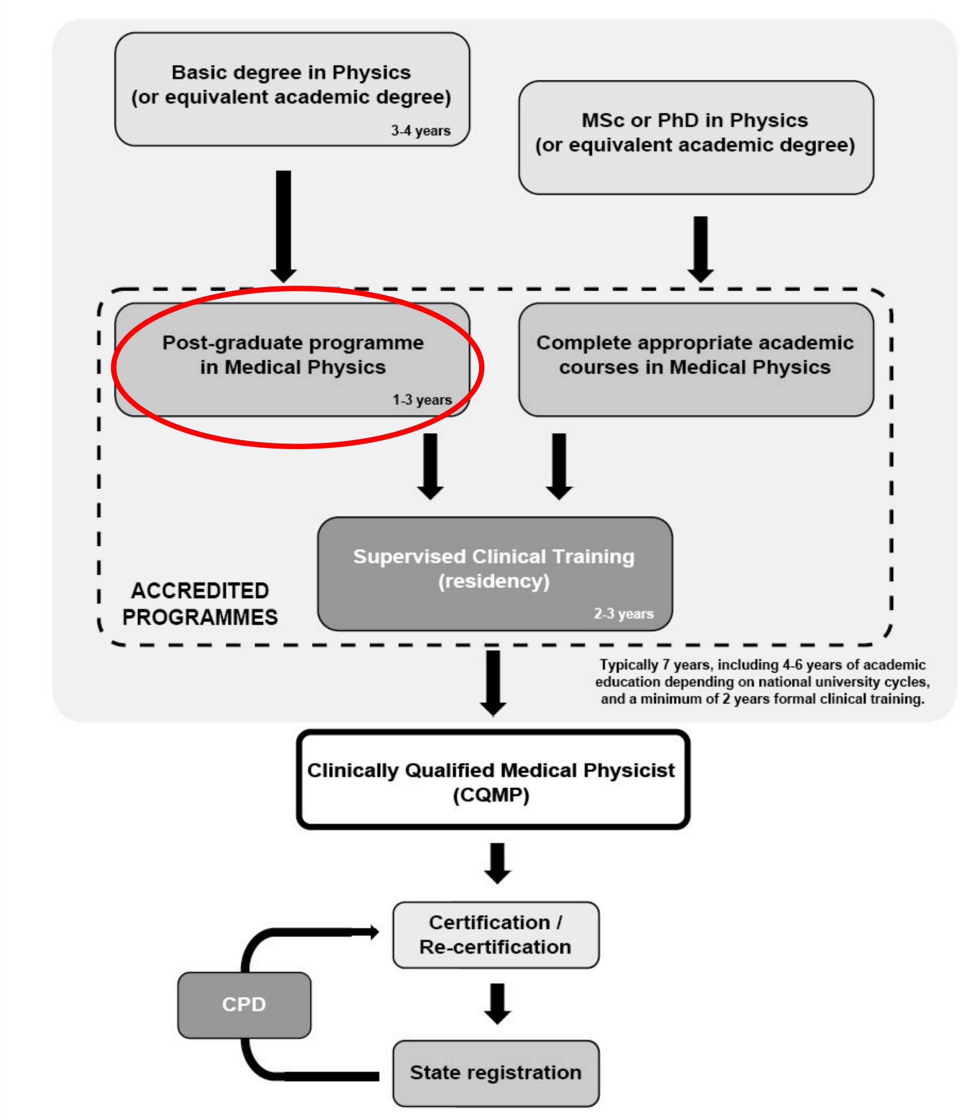

FIG.1. Minimum requirements for the academic education and clinical training of a Clinically Qualified Medical Physicist. (INTERNATIONAL ATOMIC ENERGY AGENCY, Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, INT/6054, Human Health Series No. 25, IAEA, Vienna (2013).)

For the foreseeable future, in order to expedite affordable capacity building for clinical medical physics in the region and to promote the establishment of national programmes, clinical training in only one discipline will most likely be considered acceptable (1 year clinical training in radiation oncology or 6 months in nuclear medicine medical physics or 6 months in radiology medical physics). However, 1 year clinical training, providing competence in both nuclear medicine and radiology is highly desirable to promote the role of medical physics in imaging. The aim of the academic programme should therefore be to prepare a student for entry into any one of these clinical training routes.

National academic centres, even with limited radiation medicine facilities, can be encouraged to initiate programmes using the resources that are available. This may be limited to an academic offering only or be conducted as a sub-regional cooperative effort in order to optimize resources. All programmes should ideally result in appropriate national recognition and accreditation.

2. ACADEMIC PROGRAMME STRUCTURE

The academic education of medical physicists must include all clinical disciplines, i.e. radiation oncology, radiology and nuclear medicine, and include radiation protection as it is applied to the clinical environment. The duration of the academic education program will be determined by the national qualification framework according to the structure, content, level and certification process.

2.1.INFRASTRUCTURE

A postgraduate academic university qualification or certification should be associated with the programme. The academic programme would be the responsibility of, or alternatively under the supervision of, at least one clinically qualified medical physicist. The establishment of new programmes must not have a negative impact on clinical medical physics service delivery. Ideally the programme leader would have a PhD in the field of medical physics. Clinical medical physicists and other professionals working in the health care sector may complement the faculty.

No student assessment and/or evaluation criteria are recommended, as this would be the autonomous decision of university.

2.2.MODULES

The content of the academic programme has been divided into 3 levels: core, recommended and elective. This has been done in order to allow the local faculty to develop a programme which is adapted to the knowledge of the graduates entering the programme, the local resources and the graduate degree equivalence, which is known to differ across the region.

The following subjects are considered the *core* (essential) modules to the academic programme:

- Radiation Physics
- Fundamental of dosimetry
- Physics of Radiation Oncology
- Physics of Radiology
- Physics of Nuclear Medicine
- Radiation Protection and Safety (ionising and non-ionising)

Some of these modules may have been covered in the undergraduate degree, or be an integral part of the clinical training programme therefore several different permutations are possible. In addition, the content of the Radiation Physics module for instance, may be included in the discipline-specific modules. Use of this document in the accreditation and auditing of individual programmes will therefore require close scrutiny of the detailed content of each topic.

The following subjects are ***recommended*** modules:

- Measuring techniques, statistics and research methodology
- Radiobiology
- Anatomy and Physiology
- Professional and Medical Ethics

The following subjects are ***elective*** (or optional) modules:

- Information technology with an emphasis on networking
- Electronics
- Medical Physics practical sessions in the Hospital. If available, the academic programme should include basic practical exercises/training in radiation oncology, nuclear medicine and radiology, in order to expose students to the profession.
- Research report

2.3.FACILITIES AND REFERENCES

There should be Internet access for the students and at least online journal subscriptions for the major scientific societies, journals and resources in the field of medical physics, e.g. The Journal of Applied Clinical Medical Physics, Applied Radiation Oncology, International Society of Radiology, Medical Physics International, http://humanhealth.iaea.org, etc.

The availability of the following references was considered essential:

1. PODGORSAK, ERVIN, Radiation Oncology Physics: A Handbook for Teachers and Students, IAEA, Vienna (2005)
2. INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Medicine Physics: A Handbook for Teachers and Students, IAEA, Vienna (under preparation) (2013)
3. INTERNATIONAL ATOMIC ENERGY AGENCY, Diagnostic Radiology Physics: A Handbook for Teachers and Students, IAEA, Vienna (under preparation) (2013)
4. CHERRY, S.R., SORENSEN, J.A., AND PHELPS, M.E., Physics in Nuclear Medicine, Saunders, Philadelphia (2003)
5. BUSHBERG, JERROLD T., ET AL, The Essential Physics of Medical Imaging, Lippincott Williams & Wilkins, Philadelphia (2011).
6. PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), Springer, New York, USA (2010)

7. KHAN, FAIZ M., The Physics of Radiation Therapy, Lippincott Williams & Wilkins, Philadelphia (2009).
8. VENSELAAR, J., MEIGOONI, A. S., BALTAS, D. and HOSKIN, P. J., Comprehensive brachytherapy: Physical and Clinical Aspects, Taylor and Francis, Florida (2013).
9. INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards - Interim Edition General Safety Requirements Part 3, IAEA, Vienna (2011)

3. PROGRAMME CONTENT

3.1.CORE MODULES

The contents of the six core topics must be included in the academic programme however they may be re-structured into different modules. In each case, the content of each module is given.

3.1.1. Radiation Physics

Objective: The purpose of this module is to comprehend the basic principles of radiation physics in order to apply them to medical physics. The interaction of photons, charged particles and neutrons with matter is described. The essential properties of atomic nuclei are also described. Characterization of attenuation must be understood.
Content:

- Introductory concepts to modern physics
- Atomic and nuclear structure
  - Basic principles
- Radioactivity
  - Radioactivity decay mechanisms
  - Radioactive decay law
    - Half-life
    - Activity
    - Secular equilibrium
- Basic nuclear interactions
- Interaction of radiation with matter
  - Photon interactions
    - Photoelectric interaction
    - Compton
    - Pair production
    - Rayleigh and Thomson
    - Attenuation
    - Cross-sections and relative importance of interaction mechanisms
  - Charged particle interactions
    - Elastic scattering
    - Inelastic scattering (collisional and radiative processes)

        - Stopping power concept
        - Continuous slowing down approximation (CSDA) and range concept
        - Bragg peak concept
    - Neutron interactions
        - Energy classification
        - Elastic and inelastic interaction
        - Interaction law (attenuation)
- Introduction to Monte Carlo methods

3.1.2. Fundamentals of Dosimetry

Objective: The purpose of this module is to comprehend the physical basis of dosimetry, introduce different theories and describe the principle of operation of the various types of dosimeters. Standard quantities and units are introduced so that dosimetric formalisms of radioactive decay, radiation interactions and the radiation field can then be discussed. All radiation measurements rely heavily on applications of charged-particle equilibrium and/or cavity theory; hence these areas must be covered in detail.

Content:

- Fundamental concepts of dosimetry (energy transfer and deposition)
- Quantities and units according to the International Commission on Radiological Units and Measurements (ICRU)
    - Activity
    - Fleunce, energy fluence, planar fluence
    - Exposure, kerma, cema
    - Absorbed dose
    - Equivalent dose
    - Effective dose
    - Relationship between various quantities
    - Electronic equilibrium concept
- Cavity theory and charged particle equilibrium (CPE)
    - Bragg-Gray theory
    - Spencer-Attix theory
    - Burlin theory
    - Total CPE
    - Transient CPE
- Fano theorem
    - concepts
- Detectors and dosimeters
    - Gas based dosimeters
        - Ionization chamber
        - Geiger-Müller counter
        - Proportional counter
    - Solid state dosimeter
        - Thermoluminescence
        - Scintillation
        - Diodes
        - Mosfets
        - Others (flat panels, Photo Stimulable Phosphors (PSPs), etc.)
    - Chemical dosimeters

        - Film
        - Frick
        - Gel
    - Calorimetry
- International radiation dose calibration chain
    - Formalisms
    - Primary Standard Dosimetry Laboratories (PSDLs)
    - Secondary Standard Dosimetry Laboratories (SSDLs)
    - User cross-calibration

3.1.3. Physics in Radiation Oncology

Objective:
The student is introduced to the physical principles and the technical aspects of all steps of the radiotherapy process and the essential elements of Quality Management in radiotherapy. The principle and the operating modes of the different equipment used in radiotherapy is given, including facility design. The definition and use of quantities to describe the radiation beams and radioactive sources used in radiotherapy, is given. The student must comprehend the essential elements of dosimetry and patient treatment planning, including definition of the volumes to be irradiated, patient data acquisition, dose distribution (2D & 3D) calculation, evaluation and verification.
Content:

- External Beam Radiation therapy equipment
    - Functional principles and safety aspects of:
        - ^{60}Co unit
        - Linear accelerator (photons and electrons)
        - Simulator
        - Computed Tomography (CT)
        - Treatment Planning System (TPS)
        - Record and verify systems (RVS)
    - Dosimetry equipment
        - Absolute and relative dosimetry system
        - Water phantoms
        - In-vivo dosimetry (IVD) (e.g. diodes, metal oxide semiconductor field-effect transistors (MOSFETs), etc.)
        - Film dosimetry
- Photon beams
    - PDD, Profiles, Isodose curves (concepts)
    - Dose ratios (e.g. percent depth dose (PDD), tissue-maximum ratio, etc.)
    - Output factors (e.g. head scatter factors, total scatter correction factor, etc.)
    - Factors influencing dose distribution (e.g. field size, energy, etc.)
    - Treatment time and Monitor unit calculations and dose tables (equivalent square, PDD tables, …)
    - Manual dose calculation (Extended source surface distance (SSD), two opposing fields, …)
- Electron beams
    - PDD, Profiles, Isodosecurves (concepts)
    - Range and energy concepts
    - Monitor unit calculations and dose tables

    - Output factors (applicator factors, cut-out factors, …)
    - Bolus
- Beam calibration
    - Specification for beam quality (kV & MV photons & electrons)
    - Absolute dose measurement
    - Code of practices (IAEA TRS398, IAEA TRS 277, etc.)
- Imaging in Radiation Oncology
    - Simulator (fluoroscopy, CT-simulation, simulator-CT)
    - CT
    - Portal imaging
    - Other modalities (Magnetic resonance imaging (MRI), Angiography, single photon emission computed tomography (SPECT), positron emission tomography (PET) and Image fusion in radiotherapy)
- Immobilisation and localisation for radiation oncology
    - Immobilization devices (thermoplastic, foam, breast board, etc.)
    - Contouring devices
- Treatment planning
    - Volume definition, prescribing and reporting (ICRU 50, 62 & 83)
    - Dose prescription and constraints (tolerance)
    - Planning techniques
    - Multiple beam planning
    - Matching and abutting photon and electron beams
    - Basic dose calculation algorithms
    - Principles of advanced dose calculation algorithms
    - Treatment optimisation and evaluation (dose volume histograms, beam’s eye view, digitally reconstructed radiographs, etc.)
        - Beam shaping and modifying devices (wedges, compensators, bolus, blocks, etc.)
        - Interpretation of dose prescription (homogeneity index
    - Heterogeneity and irregular surface corrections
    - Beam data introduction, modelling and verification
- Principles of quality assurance in radiotherapy
    - Quality Assurance (QA) concepts (standards, tolerance, etc.)
    - QA of radiotherapy equipment
        - Mechanical quality control (QC)
        - Dosimetric and beam characteristics QC
    - Data transfer verification
    - TPS QA
    - QA of patient position and immobilization
    - Audits
    - Peer review and comprehensive QA
    - incident and near accident reporting in radiotherapy
- Informatics and networking
    - Principles of information systems and networking in radiotherapy
    - Digital Communication Standard (DICOM) RT,
- Brachytherapy
    - Source strength and specification of radioactive sources
    - Source calibration
    - Principles and functioning of remote and manual afterloading (low- and high-dose rate, applicators)

  - Imaging in brachytherapy
  - Dose and volume specification
  - Treatment techniques and dose calculation(Paris system, AAPM TG43 formalism, …)
  - Treatment planning
  - QA in brachytherapy (source strength, source positioning, equipment, etc.)
  - IVD
  - Safety (emergency procedures)
- Facility design and shielding calculation and verification

3.1.4. Physics in Nuclear Medicine

Objective:
The student is introduced to the physical principles and the technical aspects of all nuclear medicine modalities and equipment, including facility design, as well as the essential elements of Quality Management in nuclear medicine. This course addresses the production and use of radionuclides in diagnosis and therapy, nuclear medicine image formation and internal dosimetry
Content:

- Radionuclide production
  - Generators
  - Cyclotrons
  - Reactors
- Radio-pharmacy
  - preparation of labelled materials,
  - in-vivo and sample measurement techniques
  - principles of tracer kinetics
  - QC on radiopharmaceuticals
- In vitro techniques
  - Radioimmunoassay (RIA)
  - Reagent
  - Well counters
- NM instrumentation
  - Dose calibrators
  - Well counters
  - Probes
  - computers and networking
- NM imaging devices
  - gamma cameras,
  - SPECT,
  - PET
  - hybrid systems
- Image reconstruction, processing and analysis (including fusion)
  - Signal analysis
    - Basic analysis tools and techniques for digital processing of signals
    - Operations associated with the process of converting an analogue to digital form suitable for digital processor
    - Advantages of digital over analogue signal processing
    - Continuous time vs. discrete-time signals
    - Convolution

            - Fourier transform
    - Image manipulation
    - Theory of tomographic reconstruction
    - Filtered back-projection
    - Iterative reconstruction
    - Scatter correction
    - Attenuation correction
    - Image co-registration (fusion)
- Quantitative imaging
    - Standard uptake value (SUV) measurement
    - Ejection fraction
    - Renal function test
    - Thyroid uptake
- Principles of QA in nuclear medicine
    - Dose calibrator
    - Scintillation probes and well counters
    - Gamma camera and SPECT
    - PET and PET-CT systems
    - Audits
    - Peer review and comprehensive QA
    - incident and near accident reporting in nuclear medicine
- Diagnostic applications in Nuclear Medicine (planar, tomographic and functional)
    - Static and dynamic studies
    - Saturation analysis
    - Tumour localisation
    - Organ function
    - Absorption studies
    - Metabolic studies
- Radioactivity measurements and internal dosimetry
    - Medical Internal Radiation Dosimetry (MIRD) formalism
    - Radiation dose from nuclear medicine radiopharmaceuticals
    - Breast feeding and pregnancy
- Diagnostic reference levels
- Radionuclide therapy
    - Activity measurements
    - Therapeutic procedures
    - Safety aspects (administration, isolation, design specification, waste management, patient discharge)
    - Sterile procedures (^{90}Y, etc.)
- Facility design and shielding calculation and verification

3.1.5. Physics in Radiology

Objective:
The student is introduced to the physical principles and the technical aspects of all modalities used in diagnostic and interventional radiology, including facility design, as well as the essential elements of Quality Management in radiology. The principle and the operating modes of the different equipment is described, from the production of X rays to the formation of a medical image, as well as non-ionizing modalities used in diagnostic radiology.

Content:

- X ray production
    - Principle of X rays production, X ray spectrum
    - X ray tubes (stationary & rotating)
    - Line focus principle and heel effect
    - Factors influencing the output
- X ray Imaging detectors (conventional/digital)
    - Films & cassettes
    - Computed radiography (CR)
    - Direct and indirect flat panels
    - Image intensifier
    - Gas ionization chambers
    - Solid state detectors
    - Image formation (analogue & digital)
- Planar imaging (radiography/fluoroscopy)
    - Projection radiography (magnification, penumbra, etc.)
    - Fluoroscopy
    - Television channel
    - Digital Subtraction Angiography
    - Anti-scatter grid
    - The Bucky table
    - Automatic Exposure Control (AEC)
    - Artefacts
    - Image quality (noise, resolution, contrast)
- Breast imaging/mammography
    - Mammography X ray tubes (Target, focus spot, filtration, etc.)
    - Line focus principle and heel effect
    - Factors influencing the output (breast compression, thickness & density, magnification, patient positioning, AEC, etc.)
    - Image requirements (analogue & digital)
    - Artefacts
- CT
    - Components
    - Generations (4)
    - Principle of image reconstruction
    - Multi-detector CT, helical CT (pitch, Sinogram)
    - Detection technology
    - Collimation
    - Concept of CT number
    - Image manipulation and post-processing including windowing
    - Image quality (noise, resolution, contrast)
    - Artefacts
- Basic physics and applications of MRI
    - Principle of nuclear magnetic resonance (NMR)
    - Generation of resonance magnetic signals
    - Free induction decay, T1 relaxation, T2 relaxation
    - Pulse sequences (T1, T2 weighting)
    - Gradient (slice selection, frequency encode and phase encode)
    - Component of MRI device
        - Magnet

        - Coils
        - Detectors
        - shielding
        - processor
    - image quality (noise, resolution and contrast)
    - Artefact
    - Safety and bioeffects
- Basic physics and applications of Ultrasound imaging
    - Principles of ultrasound generation and interaction (transducer and transducer arrays, reflection, transmission and refraction)
    - Beam properties (near field, far field)
    - Principle of image generation (A mode, B mode, TP mode)
    - Doppler US (continuous, pulse,
    - image quality (noise, resolution (axial, lateral and elevation) and contrast)
    - Artefact
    - Safety and bioeffects
- Additional imaging modalities
    - Principles of dental radiography/panoramic
    - Principle of Dual X ray energy Absorptiometry
    - Contrast enhancement studies (contrast agents)
- Image, processing and analysis
    - Filters
    - Kernel and convolution
    - Fourier analysis
    - Fusion
    - Segmentation
    - Computed Aided Detection and Diagnosis
- Patient/clinical dosimetry
    - IAEA TRS457
    - Organ dose and organ risk estimation
    - Diagnostic reference levels
- Image quality evaluation and optimisation
    - contrast, resolution, noise
    - Artefacts
- Principles of quality assurance in radiology
    - QA concepts (standards, tolerance, etc.)
    - QA of radiology equipments
    - Audits
    - Peer review and comprehensive QA
    - incident and near accident reporting in radiology
- Networking in radiology
    - Principles of Picture Archiving and communications (PACS), Hospital Information systems (HIS) and Radiology Information Systems (RIS)
    - DICOM
- Facility design and shielding calculation and verification

3.1.6. Radiation Protection and Safety (ionising and non-ionising)

Objective:

The course introduces the basic principles of radiation protection as applied in the clinical environment. Attention is given to safety, radiation survey instruments, waste management and emergency procedures in medical environment.
Content:

- Principles and philosophy
  - justification, optimisation (As Low As Reasonable Achievable) and dose limitation
  - Radiation effects
  - Quantities and units
- Regulatory infrastructure
  - IAEA interim Basic Safety Standards (BSS), BEIR, International Commission on Radiological Protection (ICRP), etc.
  - National regulations
- Radiation survey instruments
  - Calibration and operation
  - Personnel dosimetry
- Waste and source management and transport
  - Radiotherapy
  - Nuclear medicine
- Occupational, medical and public exposure
- Radiation emergency procedures
  - Radiotherapy
  - Nuclear medicine
  - Radiology

3.2.RECOMMENDED TOPICS

3.2.1. Measuring techniques, statistics and research methodology

Objective:
This teaching aims to provide the student with the capacity to make a descriptive analysis of data using probability models, to describe the fluctuations of a measurable or countable characteristic and to use statistical methods to describe uncertainties (table, graph, calculation of average, standard deviations, etc.). Students should be familiar with research methods and ethics pertaining to human subjects. Scientific communication, literature reviews and writing skills are necessary outputs. The ability to concisely, accurately, and fluently communicate research methods and results to a variety of audiences is essential in science. The medical physics student should be exposed to, and participate in, activities such as the preparation of proffered abstracts for scientific meetings, the creation of posters for such meetings, the oral presentation of research at such meetings, the preparation of manuscripts for peer review and the scientific review of manuscripts submitted to peer-reviewed journals.
Content:

- Calculation of results
- Statistical analysis and uncertainty estimation
- Literature review and copyright
- Proposal design and research ethics
- Scientific writing and plagiarism
- Presentation skills

3.2.2. Radiobiology

Objective:
This course aims to provide the basic connection between microscopic and molecular interactions of radiation with tissue leading to the biological response of cells to radiation, with the physical interaction mechanisms. It provides the basic background for understanding the effects of radiation on human tissues and the resulting safety policies and therapy regimens.
Content:

- Classification of radiation
- Effects of radiation on cells, tissues and organs
- Radiation damage and repair
- Survival curves
- Dose rate effect
- Fractionation (time-dose, volume index)
- Pregnancy (radiation effects on embryo and foetus)

3.2.3. Anatomy and Physiology

Objective:
The objective of this course is to familiarize the student with the common anatomical and physiological terminology needed to communicate effectively in the clinical environment. The basic knowledge of structure, topography and function of different systems and organs related to radiotherapy and imaging, should be presented.
Content:

- Anatomical nomenclature
- An introductory course on the structure and function of the main organ systems in the body (concepts)

3.2.4. Professional and Medical Ethics

Objective:
This material is intended to cover ethical issues in clinical medicine and in the professional conduct of the medical physicist. The term “ethics” is used here in the sense of a permissible standard of conduct for members of a profession. In addition to becoming familiar with written codes of conduct, the student should be introduced to commonly encountered situations in which a choice of actions is available, some of which would be considered unethical (and some of which would be considered ethical), according to current international and national standards of care or practice.
Content:

- Ethical principles
- Professional conduct
- Clinical practice ethics

3.3.ELECTIVE TOPICS

Elective topics are not mandatory and are generally included when a substantial amount of didactic material and coursework is needed to meet the requirements of the local university. Some suggestions are given below but they are not considered essential to all programmes.

3.3.1. Information technology with an emphasis on networking

Objective:
Information technology is an essential component of the tools that a medical physicist needs to perform basic tasks in the practice of medical physics. This section provides an introduction to some of these basic information technology skills.

3.3.2. Electronics

A basic theoretical and experimental course on the electronic components and functioning of devices and system typically used in a medical physics environment can be included here.

3.3.3. Practical sessions in a hospital

Medical Physics practical sessions in the Hospital

- Radiation Oncology
- Nuclear medicine
- Radiology

3.3.4. Research report

A research project could be included here.

3.4.RELATIVE CREDITS

Table I gives an example of the relative credits that can be used to determine the contact hours of the programme. It should be noted that difference permutations are possible within the academic programme structure because some modules may be covered during the clinical training, whereas other modules may be part of the pre-requisite learning received during the graduate programme. In addition, many postgraduate programmes require a significant research report component, which is not included here.

TABLE 1. AN EXAMPLE OF A POSTGRADUATE PROGRAMME WHICH INCLUDES ALL THE MODULES SUGGESTED IN THIS DOCUMENT. THE RELATIVE CREDIT REFERS TO THE CONTACT HOURS AND DOES NOT ALLUDE TO A RATING OR GRADING SYSTEM.

Module	**Relative credit within the programme**
Radiation Physics	10%
Fundamental of dosimetry	10%
Physics of Radiation Oncology	12.5%
Physics of Radiology	12.5%
Physics of Nuclear Medicine	12.5%
Radiation Protection and Safety (ionising and non-ionising)	12.5%

Measuring techniques, statistics and research methodology	5%
Radiobiology	7.5%
Anatomy and Physiology	5%
Professional and Medical Ethics	2.5%
Information technology with an emphasis on networking	1.25%
Electronics	1.25%
Medical Physics practical sessions in the Hospital	7.5%

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RAF 6/044 Task Force Meetings
Johannesburg, South Africa: 21-24 September 2011
Vienna, Austria: 21-25 May 2012
Vienna, Austria: 8-12 April 2013

RAF 6/038 Task Force Meeting
Vienna, Austria: 4-6 February 2013