# CURRICULUM
# MEDICAL PHYSICS EXPERTS

Integral curriculum

College Consilium of the Stichting Opleiding Klinisch Fysicus
www.stichting okf.nl

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# Contents

## INTRODUCTION

The Medical Physics Expert (MPE) applies physics principles in the medical setting [1,2,3,4,5]. In the Netherlands, the expertise and official requirements for training of the MPE are defined by law [6,8]. The MPE has three main responsibilities:

1. Quality Assurance: clinical introduction, development, quality assurance of medical technology for diagnosis and treatment, and continuous development of a quality management system. The MPE is also qualified to advise on and act in radiation protection matters and/or other subjects within the domain of physics,
2. Diagnosis and treatment: the MPE advises on, and is responsible for some aspects of, the diagnosis and treatment of individual patients. The MPE is responsible for effective and correct use of medical devices and the correct dose delivery for diagnostics and treatment, both for the individual patient as well as the entire patient group.
3. Innovation: initiating innovations to improve diagnostics and treatments as well as performing scientific research and translating the results into new methods for diagnosis and treatment. The MPE also determines and develops, together with medical doctors and the hospital management, the strategic and medical-physics policy of the hospital and/or department.

The field of expertise of the MPE ranges from acquisition, development, innovation, clinical implementation, and quality management of medical technology, to ensuring and optimising the quality of diagnosis and treatment of individual patients [6,9]. The common goal is to enable and ensure the optimal, safe and reliable diagnosis and treatment of patients. For this, expert knowledge on fundamental physics, technical equipment and information technology possibilities, interpretation of diagnostic and therapeutic data, and understanding of characteristics of the patient's disease is required. MPEs play an active role in scientific research and innovation in medical technology aimed at continual improvement of treatment and diagnosis. In patient care, the role of the MPE in the multi-disciplinary medical team varies from primary treatment responsibilities to the responsibility for the safe and correct introduction and use of state-of-the-art medical technology and techniques. The MPE is also responsible for ensuring the radiation safety of patients, hospital staff and the general public.
MPEs play a leading role in the strategic planning, commissioning, and safe use of technology and techniques, and therefore are also actively involved in the continual improvement of diagnostic and treatment techniques and technological advancements.

In technology-driven medicine, the MPE works in close collaboration with the physician and other technical healthcare professionals such as engineers and technicians. The MPE is the specialist trained in applying fundamental and applied physics, mathematics and technology in the clinic at an academic level. The MPE is responsible for applying medical physics knowledge and skills for the benefit of the individual patient.

Therefore, a Master in Physics or equivalent is a prerequisite to enter the four-year post-Masters residency program to become an MPE. Only equivalent Master programmes in the Netherlands approved by Stichting OKF are accepted (https://www.stichtingokf.nl/belangrijke-documenten/geaccepteerde-vooropleidingen/). [6, article 6]

The purpose of this document is to describe the competences that an MPE needs to achieve during training, as well as to describe the minimum required knowledge and skills. Each topic is divided into competences, knowledge and skills required for all MPEs, and for MPEs in each of the sub-specialisms, which are Radiotherapy, Radiology and Nuclear Medicine, General Medical Physics and Audiology.

**Curriculum describing knowledge, skills and competences**

In order to acquire and maintain sufficient knowledge, skills and an appropriate level of competence, both initial and continuing education and training are necessary. The training and education are structured by the Core Curriculum of an MPE's education. The Core Curriculum describes the knowledge, skills, and competences that the MPE in training needs to acquire during the four years of training. It is based on the previous curricula of the Stichting OKF, and the European Core Curriculum for radiotherapy by ESTRO in 2011 [6,2011], and on the curriculum for medical specialists, which applies the CANMEDS methodology that describes the development of competences. Further, the curriculum complies with the Dutch Healthcare Professionals Act (in Dutch: Wet op de beroepen in de individuele gezondheidszorg – BIG act), which addresses the required knowledge, academic training and attitude of the MPE. These requirements are described in the 'MPE', 'Scholar' and 'Additional Competences' sections of this Curriculum respectively. In 2015, the CANMEDs competences were updated [7].

The previous curricula (latest version 2018) consisted of a general part, volume 1, describing the General Competences and the Fundamental Knowledge, Skills and Competences for all MPEs, and a specific part, volume 2, describing the Knowledge, Skills and Competences for each specific field of expertise.

The contents of the chapter of the current Curriculum are as follows:

**I**
Provides information on the individual plan of education for an MPE resident as well as evaluation methods.

**II**
This chapter states the seven general competences, which the MPE should master at the end of his/her training. Achieving the competence "MPE" is the overall goal of the curriculum and integrates all of the other six competences: Collaborator, Communicator, Health Advocate, Leader, Professional and Scholar. These general competences should be achieved by completing courses, performing clinical, innovation, and research projects, and / or (patient) counselling.

**III**
In chapter III, the former basic requirements and curriculum items (also defined in the BIG act [8]) are stated. It specifies fundamental knowledge, skills and competences. These are common topics for all MPEs (Common Trunk). Specific topics for each field of expertise are also described.

**IV**
This chapter concludes with Science and Innovation (60 ECTS). The total period for both the Common Trunk and the specific (subspeciality) part of the training, including Science and Innovation, is 240 ECTS.

**Definitions**

- Resident: MPE trainee
  The person following the four-year program to become a Medical Physics Expert.
- Knowledge
  The outcome of the assimilation of information through learning or experience; the theoretical, factual or practical understanding of a subject.
- Skills (is able to)
  The ability to apply knowledge to complete tasks and solve problems.
- Competences
  The demonstrated ability (in terms of autonomy and responsibility) to use knowledge, skills and personal, social and/or methodological abilities, in work or study and in professional and personal development.
- Deliverable
  A certain activity or a certain number of activities
- ECTS: European Credit Transfer and Accumulation System, in the Netherlands, 1 ECTS = 28 hours and 60 ECTS = 1 year

**References**

[1] International Organisation for Medical Physics, www.iomp.org

[2] Nederlandse Vereniging voor Klinische Fysica, www.nvkf.nl

[3] Stichting Opleiding Klinisch Fysicus, www.stichtingokf.nl

[4] European Federation of Organisations for Medical Physics, www.efomp.org

[5] American Association of Physicists in Medicine, www.aapm.org

[6] Staatsblad Besluit van 25 april 2005: Besluit opleidingseisen en deskundigheidsgebied klinisch fysicus, (http://wetten.overheid.nl/BWBR0018235/ )

[7] CanMEDS 2015 Physician Competency Framework,
http://canmeds.royalcollege.ca/uploads/en/framework/CanMEDS%202015%20Framework_EN_Reduced.pdf

[8] Wet op de beroepen in de individuele gezondheidszorg
http://wetten.overheid.nl/BWBR0006251

[9] Convenant Medische Technologie,
https://www.nfu.nl/img/pdf/16.11163_NVZ-NFU_ea_Convent_Medische_Technologie_-_definitieve_versie_2016.pdf

[10] Medical Devices Regulation:
https://www.rijksoverheid.nl/onderwerpen/medische-hulpmiddelen/nieuwe-wetgeving-medische-hulpmiddelen

# I. Structure of the training program

## 1. Personal plan of education

The curriculum describes competences, skills and knowledge, which are to be achieved partially by completing courses or theoretical studies, but mainly by working in the routine clinic, participating in clinical, innovation, and research projects, and by (patient) counselling. Appropriate projects are not continually available, as availability depends on developments in institutes or hospitals. Therefore, each resident has to design an individual plan in which she or he arranges participation in upcoming projects at the different hospitals taking part in the education of the resident in such a way that she or he has been educated and experienced in all topics of the relevant curriculum at the end of the four-year residency. Of course, the initial personal plan of education can be adjusted to new or unexpected projects during the residency, as long as the minimum requirements spent on each topic are still met.

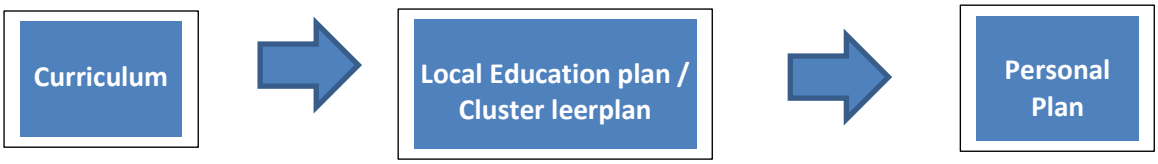


*Figure 1: How to build your personal plan using the Curriculum and Local Education Plan or Cluster Education Plan.*

## 2. Time to be spent on each topic

Four ECTS may be spent on writing the personal plan of education, and six ECTS may be spent on the progress reports. In chapter III, a minimum time (expressed in ECTS) to be spent on each specific topic of chapter III is given. A total of 80 ECTS (including the personal plan and progress reports) must be spent on the general part (Common Trunk) of the Curriculum, while each sub-specialism has additional ECTS assigned to different appropriate fields.

Courses can be used to strengthen individual competences. The resident will develop the competences required of a MPE during the full length of the training, which will involve working on projects with increasing complexity, whilst acquiring the knowledge and skills needed to work effectively as a team member.

Sixty ECTS (30 common and 30 in the specific field, which may be combined in one project) are assigned to the research project.

*Table 1: minimum ECTS in Common Trunk (for every resident) and for each specific sub-specialism.*

| Chapter | Common | General | RNG | RT | AUD |
|---|---|---|---|---|---|
| I.1 Personal plan of education | 4 | | | | |
| I.5 Progress reports | 6 | | | | |
| | | | | | |
| III.1. The patient: Fundamentals of Human Anatomy, Physiology, Psychophysics, Pathology, and Interacting with Patient | 3 | 3 | 2 | 3 | 60 |
| III.2. Physics and Engineering in Medicine* | 6 | 30 | 30 | 26 | 19 |
| III.3. Risk Management, Quality Control and Safety in the Medical Environment | 8 | 10 | 8 | 8 | 8 |
| III.4. Radiation Physics, (Radiation) Protection and Dosimetry | 12** | 5 | 5 | 10 | 0 |
| III.5. ICT and Data Science | 6 | 5 | 5 | 3 | 3 |
| III.6. Organisation, Management, Finance, Laws and Ethics in Healthcare | 5 | 0 | 1 | 0 | 5 |
| | | | | | |
| V. Science and Innovation | 30 | 30 | 30 | 30 | 30 |
| **Total** | **80** | **83** | **81** | **80** | **125** |

**Table 2 and 3 show an additional specification of this chapter*

***ECTS for Common Trunk (mainly Radiation Protection) is 12 for all sub-specialisms except Audiology (3 ECTS)*

*Table 2: minimum ECTS for Radiotherapy for Physics and Engineering in Medicine*

| | Common | RT |
|---|---|---|
| III.2. Physics and Engineering in Medicine | 6 | 26 |
| *2.2.1 Treatment equipment for external radiotherapy* | | *6* |
| *2.2.2 Treatment simulation and planning* | | *8* |
| *2.2.3 External beam treatment delivery, verification and modification* | | *7* |
| *2.2.4 Brachytherapy* | | *5* |

*Table 3: minimum ECTS for Radiology and Nuclear Medicine for Physics and Engineering in Medicine*

| | Common | RNG |
|---|---|---|
| III.2. Physics and Engineering in Medicine | 6 | 30 |
| *2.3.1 Equipment in general* | | *3* |
| *2.3.2 Image reconstruction, postprocessing & evaluation of image quality* | | *3* |
| *2.3.3 CT* | | *3* |
| *2.3.4 MRI* | | *5* |
| *2.3.5 PET/CT* | | *2* |
| *2.3.6 Gamma camera* | | *2* |
| *2.3.7 Isotopes, tracers and the radionuclide laboratory* | | *2* |
| *2.3.8 Radiography, mammography and fluoroscopy* | | *2* |
| *2.3.9 Ultrasound* | | *1.5* |
| *2.3.10 Bone densitometry* | | *0.5* |
| *2.3.11 Other equipment* | | *2* |
| *2.3.12 Diagnostic monitors* | | *1* |
| *2.3.13 Therapy* | | *3* |

# 3. Meetings, Conferences and Internships

**Attendance of meetings and conferences**

- Conferences for continuing education organised by national medical physics associations (such as the NVKF, KLIFOP and OKF)
- Relevant national (e.g., NVRO, NVvR, NVNG, NVA ) and regional meetings
- At least one international conference, e.g. ESTRO, ECMP, ASTRO, AAPM, HPA, EANM, RSNA, EFAS
- Regular participation in work-related meetings at the department of medical physics

**Internships**

- An internship of at least 30 ECTS in a non-academic setting for the candidate (see Reglement Opleiding 3.7)
- An internship of at least 30 ECTS in an academic setting (see Reglement Opleiding 3.7)
- An internship of at least 4 ECTS at each of the other sub-specialisms of medical physics
- Optional: Active participation in a national or international committee, on behalf of the NVKF or Stichting OKF (e.g., a subcommittee of NVKF)

# 4. Assessment methods to evaluate knowledge, skills and competences

Two methods for assessment of progress are suggested. These methods are mainly intended to give feedback to the resident.

**a. Multi-source feedback (MSF)**

Multi-source feedback (MSF) is sometimes termed 360-degree assessment. Specific instruments can be used to gather feedback about particular competences and skills of the resident. Feedback can be provided by completing a questionnaire-based tool.
MSF usually includes feedback solicited from two or more sources or observers. Observers can include all healthcare professionals that are involved in the resident's projects, such as physicians, nurses, technologists, and medical physics residents.
MSF can supplement traditional sources of assessment (e.g., examinations and preceptor observations) by including contributions from people who do not normally have a hierarchal responsibility for providing feedback, yet may have a different perspective on actual residents performance. Finally, MSF encourages reflection and promotes development of a self-improvement plan.

**b. Encounter cards or KPB**

Encounter cards (in Dutch: Korte Praktijk/Klinische/Deel Beoordeling - KPB, KKB or KDB) are a type of in-training tool characterised by direct observations that are documented after brief encounters between an observer or supervisor and the resident in a (clinical) setting. The encounter card is a method of direct assessment based on a short questionnaire.
Different forms are used to evaluate a project, a presentation and a clinical competence.

Examples can be found here: https://nvkf.nl/nl/documenten?field_categorie_tid=24

More methods can be found on the CANMEDS website:
www.royalcollege.ca/rcsite/documents/canmeds/assessment-tools-handbook-e.pdf

## *5. Reports on progress of education*

The progress in development of knowledge, skills and competences is monitored and assessed twice a year via a progress report (in Dutch: voortgangsverslag), which is sent for evaluation to the College of Examination (in Dutch: College van Toetsing). In this written report, the resident describes all performed activities such as theoretical studies, courses, projects, acquired knowledge and skills and patient care. The resident also reflects on the competences that were worked on during these projects, what went well, and what could be improved, and in what way the candidate is going to reach the required levels of competence. The reports can be presented as a logbook or portfolio.

In order to hold the resident accountable for the time spent on various subjects, he or she should indicate for each subject in the progress report:

1) Which objectives (knowledge, skills and competences) were covered in the project,
2) What aspect of these objectives were developed,
3) Time spent on the project, and
4) How the learning objectives were met.

At the end of the training, the resident should be able to show in the last progress report that each objective was adequately addressed (in terms of ECTS, contents and competences).

The general, sub-specialism and scientific aspects of the curriculum are spread over the four-year program. Below is an example schematic representation of main aspects of the MPE education program over time.

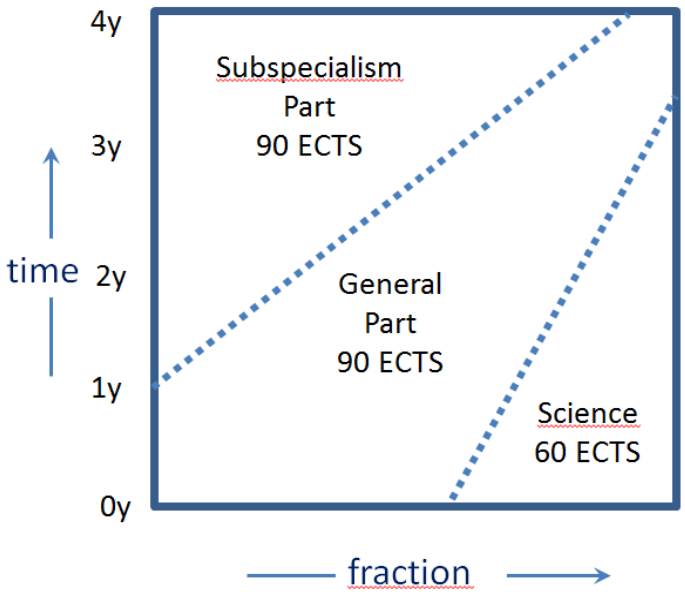


Figure 2: Example of the MPE education program over time

# II. GENERAL COMPETENCES

## 1. Medical Physics Expert

'Medical Physics Expert' is the central competence and integrates the other six competences. An excellent knowledge of the specific medical physics field, as well as an excellent knowledge of all basic and state-of-the-art techniques, including their (dis)advantages, are part of this competence. Furthermore, the MPE has a broad knowledge about physiology and pathology and up-to-date diagnostic, therapeutic and rehabilitation skills to enable him to collect and interpret relevant data.

The MPE must demonstrate and apply his or her knowledge in clinical practice through skills and appropriate attitude. At the end of the residency the MPE should be able to:

- Apply physics and medical standards in his or her department,
- Take responsibility for quality management of medical technology,
- Take responsibility for innovation and clinical implementation of (new) medical technology for patient treatment or diagnostics, and
- Advise on, contribute to, and take responsibility for the quality of the diagnosis or treatment of an individual patient.
- In addition, if the MPE is responsible for diagnosis and treatment of patients, he or she is capable of diagnosing the relevant pathology and initiating evidence-based treatment. In this case, the MPE takes full responsibility for diagnosis and follow-up.

## 2. Collaborator

In order to secure the best possible healthcare for the patients, the MPE is able to work in a multi-disciplinary team that includes physicians, medical physicists, paramedical staff, computer scientists, medical engineers, clinical technologists and administrators. This multi-disciplinary approach extends to collaboration with researchers, management of the institute, other healthcare professionals and representatives of the industry. Therefore, the MPE is able to participate in organising and structuring the clinical process and associated tasks and responsibilities. Moreover, the ability to collaborate constructively also relies on a sound understanding of one's own role within the clinical team and the necessary interactions with individuals and healthcare professional teams.

## 3. Communicator

The MPE is able to communicate in an effective, appropriate and unambiguous manner, with patients and healthcare professionals, to ensure the safe and accurate provision of healthcare services. These communication skills include communication of accurate scientific and non-scientific information, in both oral and written form, within the department, and with other departments and/or staff, colleagues, vendors, other professionals in the industry and the general public.

The MPE, especially when treating patients,

- Maintains relations with the patient and discusses the outcomes of diagnostic data and treatment options,
- Is able to give information to the patient (and their carer),
- Is able to give information to professionals and answer their questions, and

- Is able to use non-scientific language whilst ensuring clear and understandable information is given,
- Is able to communicate in Dutch on a B2 level. De minimal level in Dutch is harmonised and equal to the level required by the RGS (www.knmg.nl) and the level required for BIG registration (www.bigregister.nl). When a candidate's level in Dutch is questioned before starting a residency the candidate may be asked to test their Dutch fluency. https://www.bigregister.nl/buitenlands-diploma/procedures/verklaring-vakbekwaamheid/nederlandse-taalvaardigheid

## 4. Health Advocate

The MPE acts as a Health Advocate to positively influence the healthcare and healthcare organisations for patients and society. The MPE should:

- Understand, and be able to act within, relevant national legal frameworks, regulations and guidelines,
- Be able to act according to best use of resources in the interest of the patient and society,
- Be able to take adequate action (within his/her own competency limitations) in response to incidents/accidents,
- Show consideration for the ethical, religious, cultural and moral values of others,
- Demonstrate knowledge of ethical considerations in medical practice, and
- Know the relevant national and European healthcare legislation and guidelines and act accordingly.

## 5. Leader

The MPE:

- Manages and coordinates projects in an interdisciplinary team, both at the level of the department and at institute level,
- Advises staff and directors concerning routine medical physics services, the strategic policy of the specific department, and new developments, and
- Is able to relate department affairs (such as personnel, investments and finance) to the organisation of the institute and the organisation of healthcare in general.

If the MPE has final responsibility for diagnosis and treatment of patients, he or she is able to manage patient flows and waiting lists.

## 6. Professional

The MPE has a high standard of professionalism and integrity, self-awareness and awareness of limitations of knowledge and competences, as well as high standards of ethical and moral behavior, reliability and responsibility, respect for patient dignity, and autonomy.

The MPE

- Acts in accordance with medical ethical values in order to address dilemmas in the clinical environment,
- Knows the relevant laws for health care. Patient treatment and diagnosis is preferably evidence-based.

- Organises and performs safety and risk management, registers incidents systematically, and initiates corrective actions.

## *7. Scholar*

The field of medicine and medical physics is a dynamic, quickly evolving discipline. The MPE:

- Is able to develop, perform, and supervise research and innovation, and publish and present the research data,
- Is responsible for the introduction and implementation of new advanced diagnostic and treatment technologies along with optimisation of existing techniques,
- Should have a good national and international network and broad scientific interests, and endeavour to constantly learn and acquire new knowledge, and
- Is able to teach and train residents as well as other professionals in his or her field of expertise.

# III. FUNDAMENTAL KNOWLEDGE, SKILLS AND COMPETENCES

The following sections provide more detail on the required areas of knowledge, skills and specific competences for the MPE.

## *1. The patient: Fundamentals of Human Anatomy, Physiology, Psychophysics, Pathology, and Interacting with Patient*

### 1.1 Common Trunk

**Short description**

The MPE is part of a multidisciplinary team and has a basic knowledge of human anatomy, physiology, psychophysics and pathology; where psychophysics is the scientific study of the relation between stimulus and sensation. He or she understands diagnostic and treatment-related effects. The MPE communicates effectively with other health professionals and the patient to ensure effective healthcare.

**Knowledge, skills and competences**

The MPE has knowledge of:

- Relevant human anatomy, physiology, psychophysics and pathology,
- Radiobiology, i.e., the effects of different forms of radiation on cells,
- Basic psychological principles in the practice of medicine,
- The principles of counselling, and
- Fundamentals of patient diagnosis and treatment, and, rehabilitation.

The MPE is able to:

- Interact with patients and carers,
- Recognise basic anatomy, physiology and pathology of the major parts and organs of the human body in images created on all radiology or nuclear imaging modalities,
- Consider the high technical quality of possible treatments as well as the quality of life of the patient, medical considerations and treatment costs
- Finally, the MPE is competent in multi-disciplinary collaboration and communication.

### 1.2 Radiotherapy: Fundamentals of oncology, radiobiology and radiotherapy

**Short description**

In order to effectively communicate and operate within the multi-disciplinary team, an understanding of the fundamentals of cancer development, diagnostics and treatment is required. Knowledge of radiobiological principles and the effects of radiotherapy and multimodality treatments is also essential.

**Knowledge, skills and competences**

The MPE has knowledge of:

- The development of cancer, the nature of the various forms of cancers and their molecular and cellular features, as well as diagnostics of cancer,

- Different tumour sites and treatment options including multi-modality options such as chemotherapy or chemoradiation, surgery, immunotherapy and hormone therapy, as well as High-Intensity Focused Ultrasound (HIFU), Radio Frequency Ablation (RFA) and hyperthermia,
- Radiotherapy treatment options including radiation schemes and clinical outcomes,
- Radiobiological background of treatment strategies in radiation therapy,
- Fundamentals of radiobiological models in radiotherapy, and the application and limitations of these models,
- Dose-response analysis from clinical data and patient cohorts,
- Fundamentals of cellular, molecular and tumour biology,
- Deterministic and stochastic effects of ionising radiation,
- Effects of fractionation, dose rate, radiosensitation and reoxygenation,
- Principles of diagnostics and staging of cancer,
- Principles of surgical, medical and radiation oncology, and
- Fundamentals of radiotherapy treatment

### 1.3 Radiology and Nuclear Medicine: Medical fundamentals of diagnostics and treatment

**Short description**
Advanced knowledge of anatomy, physiology and pathology, beyond the basic curriculum requirements, is required to effectively communicate and operate in a multidisciplinary team in the departments of radiology and nuclear medicine, and to recognise and understand the underlying anatomy, physiology and pathology shown in the images produced by the different modalities.

**Knowledge, skills and competences**
The MPE has knowledge of:

- Various treatment options,
- Radiobiology, including effects of different forms of radiation on cells, differences between external beam radiotherapy, internal radiotherapy (i.e., brachytherapy), and the effects of different types of ionising radiation,
- Oncology and principles of diagnostics and staging of cancer, and
- Principles of surgical, medical and radiation oncology.

The MPE is able to:

- Identify the basic anatomy, physiology and pathology of the major parts of the body in images created on all radiology or nuclear imaging modalities,
- Apply a practical understanding of the process of how a radiologist comes to a diagnosis of different pathologies, and
- Translate the questions and challenges facing medical staff into medical physical terms.

The MPE is competent to:

- Joining different multi-disciplinary team meetings for discussion of individual patients (in Dutch: Multidisciplinair overleg - MDO),
- Participate/accompany/observe radiologist while they do their diagnosis and image analysis, for all major anatomic parts and clinical concerns, and
- Identify all major organs in images acquired via medical imaging modalities.

### 1.4 General Medical Physics

**Short description**
Advanced knowledge of anatomy, physiology and pathology, beyond the basic curricular requirements, is needed to effectively communicate and operate within a multidisciplinary team involving multiple departments within the hospital.

**Knowledge, skills and competences**
The MPE has knowledge of:

- The anatomy, physiology and pathology of for instance the cardiovascular system heart and vascular system, lungs, brain, and, gastrointestinal tract.
- Methods and techniques to assess the function or misfunction of the organ systems,
- The development of cancer, the nature of the various forms of cancers, and the associated diagnosis and treatment options, including multi-modality options, such as chemotherapy or chemoradiation, surgery, immunotherapy and hormone therapy, as well as High-Intensity Focused Ultrasound (HIFU), Photo-Dynamic Therapy (PDT), Radio Frequency Ablation (RFA), hyperthermia, radiotherapy and nuclear therapy.
- The process of how medical doctors of different specialties come to a diagnosis of a particular pathology.

The MPE is able to:

- Understand the questions and challenges facing medical staff and translate those questions in medical physical terms.

The MPE is competent to:

- Participate in multi-disciplinary team meetings for discussion of individual patients.
- Participate/accompany/observe a medical doctor while they do their diagnosis and image analysis, for all major anatomic parts and clinical topics.
- Identify all major organs in images acquired via medical imaging modalities.

### 1.5 Audiology

**Short description**
In the Dutch healthcare system, the MPE working in an Audiological Centre or audiology department of a hospital is ultimately responsible for the audiological care given to patients. As such, the MPE must have a thorough understanding of the anatomy, physiology and pathology of the ear and vestibular system, and must be able to:

- Form a diagnosis and rehabilitation plan,
- Participate in multidisciplinary teams in which diagnoses and rehabilitation options are evaluated,
- Supervise and educate other healthcare professionals,
- Communicate with patients in a clear and understandable way, and
- Effectively and efficiently manage patient care, without losing sight of the purpose and suitability of a therapy or treatment.

In short, the MPE must be able to determine what care is necessary, appropriate and sufficient, in the context of multidisciplinary patient care.

**Knowledge, skills and competences**
The MPE has knowledge of:

- The anatomy, physiology and pathology of the outer, middle and inner ear, and of the vestibular system as well as the innervation of the labyrinth and the pathways to the brain,

- Speech and language development and the associated disorders,
- Personal and environmental factors influencing the affliction and/or participation capabilities of the patient,
- The psychosocial aspects that can accompany hearing and communication disorders,
- The diagnostic and treatment options provided by the other health care professionals in the multidisciplinary team, and
- The technical and non-technical treatment options.

The MPE is able to:

- Interpret referrals of healthcare professionals and refer patients to other healthcare professionals,
- Conduct an anamnesis,
- Formulate a patient's request for help,
- Formulate a treatment plan based on the diagnostic data.
- Deliver bad news in a compassionate and appropriate manner,
- Inform and counsel patients and discuss treatment options in suitable, clear language and in accordance with their emotional state or state of mind,
- Work with patients with special needs, with an awareness of the guidance and educational possibilities for these patients,
- Provide a recommendation to a patient or insurance company,
- Refer to further care when necessary,
- Maintain a proper patient file, and
- Supervise other members of a multidisciplinary team to carry out the above-mentioned activities.

**Deliverables**

In audiology, each resident has to show to be able to conduct all of the above-mentioned skills in a system of multiple Entrusted Professional Activities (EPAs), comprising different categories of audiological care. These EPAs are:

1. Hearing diagnosis in adults,
2. Hearing rehabilitation and audiological care in adults (mainly via hearing aids or bone conduction devices),
3. Hearing diagnosis in children and infants,
4. Hearing rehabilitation and audiological care in children and infants,
5. Cochlear implants in adults,
6. Cochlear implants in children and infants,
7. Vestibulology,
8. Speech and language development in children, and
9. Tinnitus

All these EPAs are addressed throughout the four years of training within the standard clinical care of the training institute, using different levels of supervision, working from supervision level 1 to 3, 4 or 5, depending on the EPA.

Levels of supervision:

1. The resident observes (does not act).
2. The resident acts under direct, proactive supervision (supervisor is present).
3. The resident acts under indirect, reactive supervision (supervisor not present, but available when needed).
4. The resident is competent to act without supervision.
5. The resident supervises the activity.

# 2. Physics and Engineering in Medicine

## 2.1 Common Trunk

**Short description**

An MPE is an expert on the physics and engineering of medical devices and is aware of possibilities, limitations and pitfalls of their clinical application. The MPE values developments in design and functionality of these medical devices and communicates necessary or desired improvements to vendors/producers. Within the multi-disciplinary team, it is the role of the MPE to ensure that equipment used in the diagnosis or treatment process is used appropriately, effectively and safely. In addition, the MPE understands the acquisition process and interpretation of data from the various modalities.

**Knowledge, skills and competences**

The MPE has knowledge of:

- Physics and engineering principles of medical devices used for diagnostics, therapy, functional support and patient monitoring in the hospital environment (as described in more detail in sections for the sub-specialisms),
- Patient data management systems,
- Anatomical and functional imaging acquired with different modalities and techniques,
- CT, MRI, ultrasound and PET imaging devices, sources of image artefacts, image uncertainties and the resolution limits,
- The physics and principles of the different imaging modalities and the effects of the acquisition and reconstruction parameters on the appearance and the properties of an image,
- Effects and management of patient organ motion in imaging, and
- Image handling, digital image processing and reconstruction algorithms.

The MPE is able to:

- Participate in technical discussions with engineers (e.g., discussions on recalibration or replacement of parts),
- Participate in discussions with the end-users of the equipment (e.g., discussions on proper usage and technical limitations of usage),
- Initiate and support training, education and research on medical equipment.

**Deliverables**

1. Perform an acceptance test/commissioning/calibration of a medical device.
2. Write a recommendation for development/adjustment of a medical device or procedure that is in clinical use.

## 2.2 Radiotherapy

### *2.2.1 Treatment equipment for external radiotherapy*

**Short description**
The Radiotherapy MPE is responsible for the installation, maintenance, and safe and effective operation and de-installation of all radiotherapy equipment, including the integrated imaging systems to position and localise the target on-line before and/or during the treatment.

**Knowledge, skills and competences**
The Radiotherapy MPE has knowledge of:

- Physics and principles of radiotherapy treatment units (including the linac, GammaKnife, Cyberknife, proton therapy, MR-linac and orthovoltage systems),
- In-room imaging equipment (including CBCT, kV and MV imaging, MR imaging on the MR-linac, and surface scanning), and
- The sources of interlocks, and of deviations in dosimetric or mechanical parameters.

The Radiotherapy MPE is able to:

- Operate treatment units and in-room imaging equipment,
- Communicate with engineers (e.g., concerning recalibration or replacement of parts), and
- Understand the engineering maintenance and quality control of the treatment and imaging equipment.

The Radiotherapy MPE is competent to:

- Commission treatment machines and decide whether treatment machines can be clinically used.

### *2.2.2 Treatment simulation and planning*

**Short description**
The Radiotherapy MPE plays a key role in the entire treatment planning procedure, and is responsible for the dosimetry, acceptance, commissioning and maintenance of the Treatment Planning System (TPS). The Radiotherapy MPE is responsible for ensuring the effective use and operation of the CT, MRI and PET devices used for imaging. The physicist has expert knowledge of dose calculation and optimisation algorithms.

**Knowledge, skills and competences**
The Radiotherapy MPE has knowledge of:

- Mouldroom activities,
- Immobilisation devices, and their applications and accuracies,
- Hardware and software components and networking of a TPS,
- Algorithms and methods to (optimise and) calculate and evaluate the dose distribution for proton, photon and electron beams,
- Uncertainties in dose calculations,
- Photon, proton and electron plans for all treatment sites,
- Techniques to delineate organs at risk, including the use of AI, auto-segmentation and deformable registration,
- State-of-the-art proton, photon and electron treatment plans, and
- Specification and reporting of dose and volumes, margins, including international recommendations (ICRU 50, 62, 83).

The Radiotherapy MPE is able to:

- Import and model measured beam data into the TPS,
- Apply multimodality imaging data (MRI, PET) and image fusion for target volume delineation and planning,
- Appropriately incorporate implanted devices (such as prostheses, dental filings, expander valves, pace makers) into the treatment plan, including consideration of the effects of high (electron) density materials on the dose calculation, and
- Perform an independent check of the individual patient plan, using both pre-treatment dosimetry and a secondary dose calculation system.

The Radiotherapy MPE is competent to:

- Oversee the treatment planning process, and advise on its limitations and the consequences of treatment choices,
- Commission a treatment planning system,
- Advise on optimising individual treatment plans,
- Implement a new treatment planning technique to improve the treatment quality, and
- Take responsibility for the dosimetric quality of an individual treatment plan

**Deliverables**

1. Make and analyse 20 treatment plans, equally distributed over all common target areas.
2. Analyse plans for potential pitfalls in delivery, such as overmodulation, collisions and anatomical changes.

*2.2.3 External beam treatment delivery, verification and modification*

**Short description**

The Radiotherapy MPE is responsible for all procedures and techniques to verify the different aspects of the treatment, including:

- Patient positioning and target localisation with different image-guided radiotherapy (IGRT) techniques and on-line or off-line correction or plan adaptation protocols,
- Data transfer from the TPS to the treatment unit through the record and verify system, and
- Dosimetric verification of the treatment plan.

**Knowledge, skills and competences**

The Radiotherapy MPE has knowledge of:

- Patient alignment and set-up on the CT/MR and on the treatment unit,
- (pre-)Treatment dosimetric verification of standard and sophisticated radiotherapy plans
- IGRT techniques on the treatment unit using surface scanning and MV, kV, CBCT and MRI images to optimise the set-up and target localisation,
- IGRT protocols (such as off-line or on-line imaging, adaptive radiotherapy, plan of the day, and on-line replanning including the use of deformable image registration, dose summation, and workflow possibilities),
- Intra- and inter-fraction set-up errors and target motion,
- Tolerances and action levels, and
- Techniques to account for and minimise respiratory motion during pre-treatment imaging and treatment.

The Radiotherapy MPE is able to:

- Calculate the treatment (PTV) margin to incorporate the patient setup accuracy, and

- Analyse and interpret setup images and the consequences of setup errors during patient treatment.

The Radiotherapy MPE is competent to:

- Take responsibility for the continuation of the patient treatment at the treatment machine in case of deviations from the planned situation.

### *2.2.4 Brachytherapy*

**Short description**

Brachytherapy is a radiotherapy technique that uses sealed radioactive sources that are placed inside or close to the tumour. The Radiotherapy MPE is responsible for the correct use of dosimetry protocols, applicators, measurement systems and brachytherapy TPS.

**Knowledge, skills and competences**

The Radiotherapy MPE has knowledge of:

- Afterloading systems and low-dose rate permanent seed implant systems,
- The clinical application of imaging for brachytherapy,
- Functional characteristics of the source calibration equipment, and how the quality control procedures for this equipment are performed,
- Treatment planning for various sites, which must include gynaecology or prostate,
- The reconstruction of the brachytherapy needles on images and the influence of uncertainties on the dose distribution,
- Independent verifications of the calculated treatment times of intracavity insertions and interstitial implants using manual methods, and
- Basic radiation safety procedures, such as leakage tests on the sources, disposal of sources, prevention of source loss and action in case of source loss.

The Radiotherapy MPE is competent to:

- Take responsibility for the dosimetric accuracy of the treatment plan.

**Deliverables**

1. Make five brachytherapy treatment plans.
2. Be present during the preparation and treatment for three patients, including presence at the operating room, to experience the complexity and the teamwork.
3. Be present at a source replacement by the company, perform a measurement of the source activity and import this activity in the TPS.

## 2.3 Radiology and Nuclear Medicine

The Radiology and Nuclear Medicine MPE:

- Is responsible for safe and effective operation of imaging equipment,
- Is capable of optimising image quality in relation to radiation dose, acquisition time and acquisition parameters,
- Has knowledge of state-of-the-art techniques, and
- Is proactive in advising on new imaging possibilities.

In addition, the Radiology and Nuclear Medicine MPE:

- Plays an important role in training, education and research.

- All lifecycle phases of an imaging modality should be fully understood, including selection, room design, acceptance, calibration, safety and quality assurance, optimisation, and decommissioning.
- Understands and applying the physics and principles of the whole 'imaging chain' for all modalities, that includes acquisition, reconstruction, processing, displaying and post-processing.
- Understands clinical application of imaging modalities and its role in the patientcare

*2.3.1 Equipment in general*

**Short description:**
Some technology or methodology is used in multiple imaging and therapeutic equipment. This chapter describes the general concepts necessary for a Medical Physicist in the field of Radiology and Nuclear Medicine. For simplicity, all general knowledge, skills and competences for modalities are discribed in this section leaving only the specific knowledge, skills and competences for the individual modalities (section 2.3.3 and further).

**Knowledge, skills and competences**

The Radiology and Nuclear Medicine MPE has knowledge of:

- The physics of all imaging modalities,
- The different applications of each modality,
- The relationships between components of each modality and the contribution of each component in the imaging chain,
- X-ray tubes (including hardware and specifics of x-ray spectra),
- Principles of interaction between radiation and matter,
- The operating principles of different detectors,
- The effects of imaging parameters on image quality, dose and acquisition time,
- Relevant laws, reports and guidelines, and
- Protocols and phantoms for quality control.

The Radiology and Nuclear Medicine MPE is able to:

- Identify and interpret artefacts in images, and advise on the clinical impact and risks and how to these can be mitigated,
- Understand how radiological reporting is done on a broad range of diagnostic questions and modalities: implement with short clinical internships by observing reporting of radiologists.
- Operate image acquisition systems, and
- Advise on the room specifications for safe use of imaging equipment.

The Radiology and Nuclear Medicine MPE is competent to:

- Perform all aspects of the introduction of new imaging equipment,
- Perform acceptance testing, commissioning and quality control of imaging equipment, and
- Optimise image quality.

*2.3.2 Image reconstruction, postprocessing and evaluation of image quality*

**Knowledge, skills and competences**
The Radiology and Nuclear Medicine MPE has knowledge of

- The principles, methodologies and algorithms of (tomographic) image reconstruction, both in pre- and post-processing, and
- The underlying principles of image processing techniques applied to medical images.

The Radiology and Nuclear Medicine MPE is able to:

- Write and test the image processing routines in an interactive programming environment and effectively apply them to selected clinical problems,
- Apply and understand different metrics and parameters used for image quality evaluation, such as homogeneity, contrast, detail, DQE, MTF, NPS, SNR, CNR, SSIM, DICE, and MAE,
- Use Computer Aided Diagnoses (CAD), clinical decision support systems and applications of AI in radiology and nuclear medicine, and
- Identify artefacts created by image acquisition and reconstruction.

The Radiology and Nuclear Medicine MPE is competent to:

- Perform software validation (for image processing),
- Advise on artefacts created by image acquisition and reconstruction,
- Optimise and validate the quantification of biomarkers, such as:
  - Determination of stenose grade by angiography, ultrasound and CT,
  - Cardiac function by ultrasound, DSA, cardio angiography, cardio CT and MRA, and
  - Dynamic contrast enhancement by MRI, CT and ultrasound.

### *2.3.3 Computed Tomography*

**Knowledge, skills and competences**

The MPE is able to:

- Recognise the differences between and limitations of different CT apparatuses (such as spectral CT, cone-beam CT and conventional CT), and
- Recognise common CT artefacts.

The MPE is competent to:

- Optimise patient imaging protocols with respect to image quality, patient radiation- and contrast-dose
- Advise on common CT artefacts,
- Create a safe working environment for imaging activities, including CT-guided punctures and biopsies, and
- Assess and monitor diagnostic reference levels.

### *2.3.4 Magnetic Resonance Imaging*

**Knowledge, skills and competences**

The MPE has knowledge of:

- The physics of MRI signal transmission and detection,
- Acquisition parameters and their effect on the MR image,
- Imaging and contrast effects T1, T2, T2*, PD, DWI, velocity, flow, susceptibility and diffusion
- Acquisition methods and techniques (including K-space sampling schemes and fast acquisition),
- MR technology, including RF-coils, the magnet and gradient systems,

- Different applications, such as diagnosis and therapy planning (radiotherapy, neuro navigation)
- Principles, classification, safety/risks and use of MR contrast agents

The MPE is able to
- advice on a safe MRI-room, including magnetic field containment and Faraday cage
- to judge MR safety for patient contraindications and 3th company devices

The MPE is competent to
- advice on safe scanning of patients with implants
- filling role of MR safety expert in the hospital

*2.3.5 Positron Emission Tomography (PET/CT)*

**Knowledge, skills and competences**
The MPE has knowledge of
- PET radioisotopes and tracers used
- specific PET image reconstruction algorithms and all corrections applied.
- clinical indications and protocols for PET: oncology, cardiac, neurology, radiotherapy.
- quantification in PET.
- Data acquisition: singles, randoms, noise equivalent countrate, list mode, sinogram mode.
- Specific PET image reconstruction items: iterative methods (ML-EM), LOR-reconstruction, Time-of-Flight, Point Spread Function correction. Corrections and preprocessing, corrections for: geometry, normalisation, attenuation, scatter, randoms, dead time, decay, point spread, motion.
- Quantification in PET: SUVs, Patlak analysis, input function, tumour tracking software, basics of pharmokinetic modelling.

The MPE is competent to
- To do quality testing and assure guidelines: procedure guidelines nuclear medicine Dutch society of nuclear medicine, NEMA-NU2, NEMA-NU4, EARL-accreditation.

*2.3.6 Gamma camera: planar and SPECT/CT*

**Knowledge, skills and competences**
The MPE has knowledge of
- SPECT radioisotopes and tracers used
- specific SPECT image reconstruction algorithms and all corrections applied.
- quantification methods in planar and SPECT imaging
- specific SPECT image reconstruction items: Corrections and preprocessing, corrections for: geometry, normalisation, attenuation, scatter, dead time, decay, point spread, motion.
- quantification in SPECT.

The MPE is competent to
- To do quality testing and assure guidelines: procedure guidelines nuclear medicine Dutch society of nuclear medicine, NEMA-NU1.

*2.3.7 Isotopes, tracers and the radionuclide laboratory*

**Short description:**
At the basis of molecular imaging lie the radiolabelled molecules that mark a specific physiological process of the body.

**Knowledge, skills and competences**
The MPE has knowledge of

- Isotope production methods: reactor, cyclotron, linear accelerators, generators.
- properties and applications of the different tracers
- Tracers synthesis: theory and practical aspects, including quality control.
- Production of positron emitters (F-18 targetry, C-11, O-15, N-13, Ga-68, Rb-82, Cu-61/62/64)
- Dose calibrators: quality control, calibration.
- Practical safety procedures in radionuclide laboratory, incl. relevant guidelines.
- regulatory laws and guidelines applicable to production and handling of radioactive tracers in the hospital.

The MPE is able to

- be an expert in the physical properties of the different radioactive isotopes and tracer-molecules affecting imaging
- be an expert in the dosimetry and the possibilities for quantification.

The MPE is competent to

- be an expert in the design, work processes and regulations surrounding radionuclide laboratories.

*2.3.8 Radiography, mammography and fluoroscopy*

**Knowledge, skills and competences**
The MPE has knowledge of

- specific application, indications, benefits and pitfalls
- projections, image magnification, scatter and scatter rejection, both digital as with scatter grid
- differences between conventional, mammography, chest radiography and fluoroscopy
- different fluoroscopy configurations (floor, ceiling mounted, mobile, bi-plane C-arms)
- Relation to other fluoroscopy techniques, including:
  - CT fluoroscopy
  - MR-fluoroscopy.
- Different modes of operation in fluoroscopy (continuous, pulsed, averaging, last frame hold, road mapping, CT-mode)
- specific resolution requirements in digital mammography, digital tomosynthesis, stereotactic punction
- Breast cancer screeningprogram and the role of the LRCB
- Diagnostic reference levels and dose assessment

The MPE is able to

- apply these techniques in different labs: genitourinary, geniurinary, peripherical vascular and cardiac angiography, cardiac electrophysiology, neurovascular imaging and interventions

*2.3.9 Ultrasound*

**Knowledge, skills and competences**
The MPE has knowledge of

- principle, working mechanism and application of ultrasound
- Transducer techniques and systems
- Doppler, colour Doppler
- (Differential) harmonic imaging
- Contrast agents
- IVUS
- 3D ultrasound

*2.3.10 Bone densitometry*

**Knowledge, skills and competences**
The MPE has knowledge of

- theory and operation of DXA equipment and the other techniques for bone density estimation: quantitative CT
- Dual energy x-ray absorptiometry principles.
- Basic introduction to osteoporosis, bone physiology and risk factors
- Procedures for AP Spine, Femur/Dual Femur, Total Body, Forearm and LVA/Lateral spine.

*2.3.11 Other equipment*

**Short description:**
Numerous medical devices are involved in the workflow of the departments of radiology and nuclear medicine. The Medical Physics Expert should have enough knowledge and skills to take responsibility for the save utilisation of these devices.

**Knowledge, skills and competences**
The MPE has knowledge of

- of the technology of the equipment used in combination with imaging devices, specifically:
  - Contrast Injectors in different applications (Angiography, CT, MR).
  - Physiological Monitoring: e.g. ECG, heart rate (prospective and retrospective gating), respiration, apnea, (non) invasive blood pressure, cardiac output, O2-CO2 saturation (eg sedation and anesthesia by MR imaging), temperature monitoring (MR), arrhythmia and telemetry (MR)
- Gamma probes
- Dose calibrators

*2.3.12 Diagnostic monitors*

**Short description**
The 'imaging chain' starts with data acquisition and ends with displaying the image on a diagnostic monitor and the image perception of the observer. This crucial final step needs also to be fully understood by the Medical Physics Expert.

**Knowledge, skills and competences**

The MPE has knowledge of

- factors influencing the visual perception of an image on a medical display.
- the difference between displays for primary diagnosis and clinical review
- the differences between images and display criteria of different modalities (MRI, CT etc).
- the characteristics of images: compression, post processing, matrix- and pixel- size, bit depth.

Is able to

- make recommendations concerning selection of displays during purchasing process.
- make specific recommendations for viewing images of different modalities

Is competent to

- measure and optimise viewing conditions
- setup quality control program for diagnostic displays

*2.3.13 Therapy*

**Short description**

The combination of imaging and therapy becomes more abundant. These include therapies using ionising radiation (nuclide therapies, MR-Linac) and therapies based on different physical techniques, e.g. different forms of ablation.
In nuclear medicine radioactive isotopes and tracers are used to target specific regions, organs or cells in the body. These radiopharmacons are used for curing diseases and for palliative therapy.
Ablative treatments are used to achieve optimal coverage of the tumour, while minimising involvement of surrounding tissue. Image guidance, target definition and dose monitoring are common features of all these techniques. An understanding of the relation between tumour cell kill and the probability of achieving local control is essential.

**Knowledge, skills and competences**

Has knowledge of

- the principles, methodology, techniques and different radionuclides used in radionuclide therapy:
  - Radiopharmaceuticals uptake and retention
  - Uptake measurements
  - Calculation of the therapeutic activity and resulting patient dose
  - Selective internal radiation therapy.
  - Different therapeutic and diagnostic tracers/applications
  - Dosimetry software tool
  - dose-effects curves of different radiation therapies.
- Different ablation techniques in relation to imaging, including
  - High-Intensity Focused Ultrasound (HIFU)
  - Radio Frequency Ablation (RFA)
  - laser- and Cryo-ablation
- Understand interventional radiology and cardiology topics:
  - Stenting
  - PCI
- the use of image information in therapeutic treatment planning by other departments
- MR-Linac

Is able to

- Calculate patient or organ dose
- Advise on treatment plans for therapies both with ionising radiation and other ablation techniques
- taking responsibility for patient individual dosimetry and treatment planning of radionuclide therapies.
- Understand applications for 3D printing in surgical planning.
- Understand use of image information for treatment planning
    - Neuronavigation
    - Stereotactic neurosurgery
    - Radiotherapeutic treatment planning
    - 3D presentations for surgery
    - Orthopedic planning and image guidance

Is competent to

- take responsibility for patient dosimetry and safety, as is specified in dutch regulations (Bbs)
- take responsibility for the safe use of therapy in combination with MR

### 2.4 General Medical Physics

**Short description**
The General MPE is able to advise management and staff on which type of technique or equipment should (or should not) be procured or used for specific applications. In order to function as an expert and to effectively communicate and operate within a multi-disciplinary team, a thorough understanding of the physics and engineering of medical devices is required. The General MPE is responsible for the safe and effective operation of medical devices. Specific requirements in medical imaging include optimising image quality in relation to radiation dose, acquisition time or acquisition parameters, and knowledge of state-of-the-art imaging techniques.

All lifecycle phases of medical devices should be fully understood, including selection, room design, acceptance, calibration, safety and quality assurance, optimisation, and decommissioning. Furthermore, the General MPE is capable of initiating and supporting training, education and research and is proactive in giving advice on new applications of medical devices in clinical practice.

**Knowledge, skills and competences**
The General MPE has knowledge of

- Basic physics principles and working mechanisms, and safety aspects of at least the following devices:
    - Ventilator devices,
    - Monitoring devices,
    - Infusion pumps,
    - Electro surgery,
    - All imaging modalities on radiology and nuclear medicine departments
    - All ultrasound equipment throughout the hospital,
    - All devices used in areas of intensive care and monitoring (ICU, CCU, BCU, ER and OR), and
    - All lasers and ultraviolet radiation equipment.
- Signal analysis algorithms used typically in these devices,
- Signal processing and data acquisition techniques (hard- and software),
- Typical parameters settings of these devices,

- Current state-of-the-art and future developments of medical technology in several medical specialties,
- Principles of interaction between ionising and non-ionising radiation and matter,
- MR safety,
- Specific absorption rate (SAR) limits for non-ionising radiation (such as for MRI),
- Operating image acquisition systems,
- Image reconstruction algorithms,
- The effect of imaging parameters on image quality, dose and acquisition time,
- Principles of electrical safety, and
- Principles of medical gas safety.

For detailed descriptions of knowledge, skills and competences on devices used in radiology and nuclear medicine, please refer to Section II 2.3, the section for Radiology and Nuclear Medicine. These descriptions can serve as an inspiration for in-depth projects with a specific device for a resident in General Medical Physics (in Dutch: Algemene Klinische Fysica - AKF).

**Deliverables**
The resident is required to deliver at least the following items:

1. Participate in the building design process for new equipment,
2. Participate in solving artefacts,
3. Participate in image protocol optimisation for at least one type of medical equipment, and
4. Perform image quality measurements for at least two types of imaging equipment. The resident is required to take a leading role in at least one of these projects.

### 2.5 Audiology

**Short description**
As a leader of the audiological centre and as a caregiver the Audiology MPE needs to have a knowledge of the physics and engineering of the audiological devices that are used for diagnostics, and must be aware of possibilities and pitfalls in their clinical application. They also need a thorough understanding of the function and limitations of all types of hearing aids and other devices that support communication. Furthermore, they must be able to administer and adjust these devices and be able to teach others to perform these tasks. They must be able to value developments in design and functionality of these medical devices, and to communicate necessary or desired adjustments to vendors and producers.

**Knowledge, skills and competences**
The Audiology MPE has knowledge of:

- The physical properties of hearing aids, bone conduction devices and cochlear implants, and how these properties can be used to benefit the patient,
- Appropriate amplification models for hearing aids and bone conduction devices, and how to apply these models in the various devices, and
- Appropriate stimulation models for cochlear implants, and how to apply these models in different implants.

The Audiology MPE is able to:

- Perform and teach the following audiological diagnostic measurements in adults
    - Pure tone audiometry,
    - Speech audiometry (such as Pure tone, speech and Visual Reinforcement Audiometry),

    - Speech in noise audiometry,
    - Tympanometry and acoustic reflex measurements,
    - Otoacoustic emissions (OAEs), and
    - Brainstem Evoked Response Audiometry (BERA)
- Perform and teach the following specific audiological measurements in children and infants:
    - BERA and Auditory Steady State Responses (ASSR),
    - Otoacoustic emissions (OAEs),
    - Tympanometry,
    - Conditioned Play Audiometry (CPA),
    - Visual Reinforcement Audiometry (VRA),
    - Behavioural Observation Audiometry (BOA),
    - Speech audiometry, and
    - Speech in noise audiometry
- Perform and interpret performance tests on various hearing aids and bone conduction devices,
- Perform and interpret response measurements on cochlear implants,
- Verify the amplification of hearing aids with Real Ear Measurements (REM), including:
    - Verification of the various output parameters by means of real ear insertion gain, real ear aided gain, real ear aided response, et cetera, and
    - Verification by means of simulated real ear measurements in a 2cc coupler using RECD measurements.
- Validate various hearing devices using:
    - Free field tone- and speech audiometry and
    - Free field speech in noise audiometry
- Calibrate different audiological diagnostic devices

**Deliverables**

1. Calibrate and deliver a calibration report on an audiometer. (replaces 2.1 Common Trunk, first deliverable).
2. Each Audiology resident must demonstrate the ability to conduct all of the above mentioned skills in a system of multiple EPAs, comprising different categories of audiological care. The EPAs are addressed throughout the four years of training within the standard clinical care of the training institute. These EPAs are described in more detail in section 1.5.

# 3. Risk Management, Quality Control and Safety in the Medical Environment

## 3.1 Common Trunk

### Short description

Quality management requires an organisational structure (quality system) wherein responsibilities, procedures, processes and resources are clearly defined. The quality system must be compliant with all the requirements of (inter)national legislation and accreditation and requires the development of a formal quality assurance program that details the quality assurance policies and procedures.
The MPE assesses the impact of many (potential) radiological, electrical, chemical, mechanical and biological hazards to patients and hospital staff and is responsible for the quality management of medical equipment.

### Knowledge, skills and competences

The MPE has knowledge of:

- Principles of safety and risk management,
- Electrical, electro-magnetic, magnetic and mechanical safety,
- The safety management system (in Dutch: Veiligheid Management System – VMS) in place at the hospital,
- National and international guidelines and regulations (such as the Medical Device Regulation, and the Dutch convenant 'Veilige toepassing van medische technologie') [9,10]
- Quality management systems, records, audits and improvement in quality,
- Different methods of investigation following an incident to analyse its causes and consequences, and design changes to practice to avoid repetition, and
- The life cycle of medical equipment.

The MPE is competent to:

- Organise quality control and quality assurance programs.

### Deliverables

1. Participate in a quality control program for a medical device or clinical procedure.
2. Analyse a recent incident in the department.
3. Perform a prospective or retrospective risk analysis for existing or new equipment or treatment technique.

## 3.2 Radiotherapy

### Short description

Risk management and quality control is one of the main responsibilities of the Radiotherapy MPE. The MPE develops and oversees quality control programs for radiotherapy equipment and is responsible for dosimetric quality assurance and the risk management for the complete radiotherapy dose delivery chain.

**Knowledge, skills and competences**

The Radiotherapy MPE has knowledge of:

- Quality control programs of radiotherapy treatment devices,
- Patient dose verification methods, and
- Incident and near incident management systems.

The Radiotherapy MPE is able to:

- Analyse incidents and near incidents,
- Perform patient dose measurements, and
- Perform quality control measurements.

The Radiotherapy MPE is competent to:

- Take responsibility for the quality assurance of medical equipment at the radiotherapy department.

**Deliverables**

1. Participate in the incident management commission.
2. Perform acceptance testing and commissioning of a treatment unit or treatment planning system (this deliverable replaces the deliverable at 2.1).

### 3.3 Radiology and Nuclear Medicine

**Short description**

The imaging and therapeutic modalities that use x-ray, radionuclides, MRI and ultrasound are categorised as high-risk medical equipment because of the potential direct physical risks (mechanical, radiation, heating) for patients and employees and the risk of incorrect diagnosis in case of malfunctions and artefacts. Therefore, it is important to implement and maintain a quality assurance programme. The Radiology and Nuclear Medicine MPE plays a central role in the establishment and implementation of a quality assurance programme as a specialist in this field.

**Knowledge, skills and competences**

The Radiology and Nuclear Medicine MPE has knowledge of:

- The difference between quality protocols that test for the consistency (in Dutch: constantheidstesten) and in-depth quality protocols,
- Optimisation of patient safety, quality and cost,
- Calibration and use of equipment and phantoms,
- General legislation in the field of quality, including Good Laboratory Practice (GLP), ISO certification, the Quality Act, and the Nuclear Energy Act, and
- Specific procedures and protocols in the field of acceptance, and status tests (such as reports from the IEC, AAPM and IPEM and QC Light and WAD protocols).

The Radiology and Nuclear Medicine MPE is able to:

- Establish a quality assurance programme for the whole imaging department,
- Communicate with technicians, technologists and physicians on quality assurance and maintenance , and supervise quality control testing,
- Determine the clinical relevance of artefacts and surpassed quality criteria,
- Make a risk assessment based on the physical properties of the equipment used and the quality programme in place, and
- Perform acceptance testing of a large image modality.

The Radiology and Nuclear Medicine MPE is competent to:

- Take appropriate measures based on risk assessment and the results of the quality programme.

### 3.4 General medical physics

**Short description**
The General MPE is able to act as the key person on the safe use of medical technology in a hospital.

**Knowledge, Skills and Competences:**
The General MPE has knowledge of:

- Electrical safety of rooms and safety classes,
- Electrical safety of medical devices according to IEC 60601,
- Maintenance protocols,
- Cleaning, disinfection and sterilisation of medical devices,
- Recall procedures,
- Standards for quality procedures for medical devices (such as ISO 9001 and ISO 13485), and
- Specific standards, procedures and protocols in the field of acceptance, and status testing (such as reports from the IEC, AAPM, IPEM and QC Light and WAD protocols).

The General MPE is able to:

- Establish a maintenance scheme,
- Increase quality, and implement new technology and systems, and act on organisational changes and dynamics,
- Plan and overview the installation of a new medical device and communicate with the local building manager and/or facility management and manufacturer or local representative,
- Contribute to protocols to maintain or improve safe working conditions,
- Assess, or contribute to the assessment of, the level of competence that is required to safely operate medical devices,
- Define quality measures for safe and effective uses of medical devices throughout the hospital,
- Conduct a patient-related incident analysis on different levels,
- Contribute effectively to a multi-disciplinary risk analysis covering the physics aspects,
- Perform audits to monitor compliance with national legislation and agreements on medical technology, and
- Assess changes in the national legislation on medical technology and its use and analyse the implications for the hospital organisation and its quality management system.

**Deliverables**
During the training period, a resident is required to deliver at least the following items:

1. Write (or rewrite), implement and follow-up (Plan-Do-Check-Act - PDCA) at least one local guideline on quality management or closely related item,
2. Perform or participate in at least one audit or safety check of a department in which a lot of medical equipment is used,
3. For a minimum of three devices or groups of devices, a General Medical Physics resident should:
    - Compose a complete business case or compose a request for proposal, or,
    - Compose, set up and perform an acceptance test, or,

- Provide training to physicians, nurses or technicians for at least one type of medical equipment,

4. The resident is required to take a leading role in at least one of these projects. The devices included in Deliverable 3 should include, as a minimum, one device from each of:
   - Radiology or nuclear medicine,
   - The operating room or intensive care unit, and
   - Functional monitoring (for example, cardiology or audiology).

### 3.5 Audiology

**Short description**

The Audiology MPE is responsible for the care provided in the audiological center, meaning that they should be able to manage the care that is provided and take responsibility for ensuring that all equipment complies with health and safety regulations, and that all healthcare professionals are well trained. Furthermore, they need to monitor the quality and safety of equipment and of the care patients receive. They should continuously monitor and improve quality and safety of both the equipment and the content and organisation of the clinical care, and know how to handle incidents, including how to analyse them and take appropriate action to prevent them from reoccurring in the future (i.e. have knowledge of PDCA cycles).

**Knowledge, skills and competences**

The Audiology MPE has knowledge of:

- NAN and ISO norms regarding audiology.

The Audiology MPE is able to:

- Take responsibility for patient safety, the appropriate use of equipment and the quality and safety of the audiological care that is given,
- Write, optimise and maintain rules of conduct, clinical operations or procedures of audiological care, and
- Safely manage patient information according to the relevant legislation.

# 4. Radiation Physics, (Radiation) Protection and Dosimetry

## 4.1 Common Trunk

**Short description**

The MPE (with the exception of the Audiology MPE) plays a key role in radiation protection and dosimetry. The MPE has a broad knowledge of radiation physics and radiation protection in order to ensure protection of the patients, personnel and the general public in the hospital. He or she knows the physical and biological effects of radiation for exposed individuals, the relevant regulations, and methods of compliance and record keeping. This knowledge qualifies the MPE to assess the radiation risk, optimise medical exposures, and apply the ALARA and dose limitation principles in the design of radiation therapy facilities, treatment and imaging protocols. The MPE is also responsible for the application of legal regulations (such as licenses for the department).

**Knowledge, skills and competences**

* Lines marked below with an asterix do not apply to –Audiology MPEs.

The MPE has knowledge of:

- Radiation protection, ionising radiation and non-ionising radiation (such as microwave, RF and magnetic fields, ultraviolet, laser, and ultrasound),
- Generation and physical interactions of ionising radiation with matter,
- Biological effects of different types of radiation on various tissues,
- Principles of radiation safety procedures, and
- The physics, techniques and instrumentation of radiation detection systems.

The MPE is able to:

- Optimise medical exposures,
- Select equipment required to perform radiation protection measurements,
- Optimise radiation protection of patients and other individuals exposed to medical radiation, including the determination and use of diagnostic reference levels,
- Select the most appropriate detector for measurement of absolute dose and relative dose distributions under different irradiation conditions,
- Estimate measurement uncertainties, counting statistics and detection limits,
- Apply principles of patient dosimetry with radiological x-ray sources,
- Implement the local regulations of radiation protection,
- Apply the relevant national or international guidelines*, and
- Implement diagnostic reference levels (DRLs)*.

The MPE is competent to:

- Train practitioners and other staff in relevant aspects of radiation protection*,
- Advice a practitioner or patient after an incident related to ionising radiation*, and
- Advice a physician or patient about the risks of exposure to ionising radiation*.

**Deliverables**

1. The national course for radiation protection expert (RPE, in Dutch: *Coördinerend deskundige*) should be successfully completed. The relevant (Dutch) course for the Audiology MPE is the Toezichthoudend Medewerker Stralingsbescherming – Medische Toepassingen.

2. At least one of the following items:*

    - Perform a radiation survey of an area using appropriate dose-rate equipment,
    - Study or perform practical design calculations for a room in which ionising radiation will be used,
    - Plan and practice contingency measures, such as for a lost radiation source or spill,
    - Discuss decontamination procedures after a spill of liquid radionuclide with practitioners or patients,
    - Join the local Radiation Protection Commission of your department or institute, or
    - Join the local medical ethics committee as an advisor on the use of ionising radiation in human research.

### 4.2 Radiotherapy

**Short description**
Accurate dose assessment is an essential task of the radiotherapy medical physics group. The Radiotherapy MPE is responsible for the delivered dose and the correct use of dosimetry devices and protocols. The Radiotherapy MPE comprehends the calibration chain from the national primary standard to the hospital field instruments and understands the physics, techniques, and clinical use of the different dosimetry detectors involved. Determination of the absolute absorbed dose for a clinical beam under reference conditions by applying a national or international recommended protocol is a key responsibility. Methods for determination of dose in non-reference conditions must also be understood.

**Knowledge, skills and competences**
The Radiotherapy MPE has knowledge of:

- Interaction of photons, protons, and electrons in matter,
- Fundamentals of absorbed dose and KERMA,
- Fundamentals of reference dosimetry for megavoltage photon, proton and electron beams and for brachytherapy sources and orthovoltage beams,
- National (NCS) and international codes of practice for the determination of absorbed dose to water, and
- Dosimetric and measurement uncertainties through the complete dose delivery chain.

The Radiotherapy MPE is able to:

- Perform absorbed dose measurements in clinical situations,
- Set up a program for acceptance testing, calibration and quality control of the measurement systems,
- Calibrate ionisation chambers, and
- Acquire beam data for the treatment planning system.

The Radiotherapy MPE is competent to:

- Take responsibility for the absolute and relative dosimetry in the radiotherapy department.

**Deliverables**

- Participate in an external dosimetry audit.

### 4.3 Radiology and Nuclear Medicine: Dosimetry and detection

**Short description**

The Radiology and Nuclear Medicine MPE should be an authority on dosimetry of personnel, the risks of radiation and the relevant guidelines. He or she should also be capable of selecting and using the different measurement systems and software tools that are available for dosimetry and quality control. This includes acceptance testing, calibration and quality control of these measurement systems as well as estimation of the (statistical) uncertainty of measurements.
Note: The topic of patient dosimetry is specified in detail in chapter 3 of the Radiology and Nuclear Medicine curriculum.

**Knowledge, skills and competences**

The Radiology and Nuclear Medicine MPE is competent to:

- Determine appropriate treatment activity and calculate radiation dose for patients pre- and post-treatment,
- Implement a new therapeutic or diagnostic application (such as a dosimetry method or safety protocols),
- Demonstrate a good understanding of the fundamental theoretical and practical aspects of dosimetry.
- Apply principles of patient internal dosimetry with radioactive tracers (MIRD),
- Apply principles of dosimetry for personnel,
- Use software tools to calculate patient dose for both external x-ray sources and internal and external radioactive tracers, and
- Take responsibility for absolute and relative dosimetry in the radiology and nuclear medicine department.

### 4.4 General medical physics

**Short description**

The General MPE should be an authority on dosimetry of personnel, the risks of radiation, and the relevant guidelines. The General MPE should be able to function as a radiation protection expert (in Dutch: stralingsbeschermingsdeskundige - SBD) of a general hospital.

**Knowledge, Skills and Competences**

The General MPE is able to

- Be an interlocutor with the Labour Inspection (in Dutch: Arbeidsinspectie) and the radiation protection authority (in Dutch: Autoriteit Nucleaire Veiligheid en Stralingsbescherming – ANVS) regarding the regulations under the Nuclear Energy Act (in Dutch: Kernenergiewet),
- Manage the Nuclear Energy / radiation protection regulations (in Dutch: Kernenergiewet dossier) of a hospital,
- Calculate radiation protection requirements in facilities that use ionising radiation,
- Demonstrate a good understanding of the fundamental theoretical and practical aspects of dosimetry,
- Calculate the patient dose after unintended exposure of a patient to ionising radiation from medical radiological equipment,
- Estimate the foetal dose from an unintended exposure of a pregnant patient to ionising radiation from medical radiological equipment,
- Provide travel advice to a patient receiving nuclear medicine therapy, and
- Understand the role the MPE plays when a pregnant patient requires a radiologic exam at the Radiology or Nuclear Medicine department and provide advice to clinicians.

**Deliverables**

1. Perform or participate in three procurement trajectories (including procurement, installation and implementation) of new medical radiological equipment or a radiopharmaceutical laboratory device).
2. Set up at least one training programme on medical radiological equipment to users.
3. Perform calculations regarding shielding (for at least one radiological used room).
4. Compose or assist in composing a permit application for radiation protection (in dutch Vergunningsaanvraag ANVS).

### 4.5 Audiology

In Audiology, radiation physics is not a major subject of concern, as no ionising radiation is used in audiological care. Instead, noise exposure and the associated damage to the auditory system, rather than ionising radiation, is an essential area of concern for the Audiology MPE.

**Knowledge, skills and competences**

The Audiology MPE has:

- Knowledge of the effect of noise exposure on the auditory system, and the ability to apply this knowledge when counselling and advising patients, with particular consideration of work-related issues, and
- Knowledge of acoustical measurements of sound (exposure), room acoustics and speech transmission.

# 5. IT and data science

## 5.1 Common Trunk

**Short description**
The MPE understands the role and importance of Information Technology (IT) in the clinical field. He or she knows the main systems for information sharing, storage, and retrieval in a hospital and of the formats for medical data. The MPE advises on the use of medical equipment within the hospital IT system, on the use of applications such as a Patient Data Monitoring System (PDMS) or the Picture Archiving and Communication Systems (PACS), on an electronic patient record (EPR), or on the use of a patient monitoring system.
Knowledge of general IT-security regulations for collection, storage and transmission and data protection legislation, such as the General Data Protection Regulation (in Dutch: Algemene verordening gegevensbescherming – AVG) is mandatory, as well as an understanding of the role and responsibilities of the Chief Information Officer of the institute.

The MPE has knowledge of data processing, Big Data handling and Artificial Intelligence (AI), and the methods applied in commercial or in-house developed products, in order to be able to be responsible for the safe and optimal use of these products and to set up quality control programmes. In his or her work the MPE relates to management of information, (data)networks and systems.

**Knowledge, skills and competences**
The MPE has knowledge of:

- PACS, the hospital information system, PDMS, standards in medical data such as IHE, DICOM and HL7, ICT security standards for collection, storage, transmission and protection of data,
- Data safety (e.g., protected sub-nets),
- The basics and applications of Big Data analyses and machine learning (including Deep Learning),
- Electronic Health Record systems, and
- Privacy procedures.

The MPE is able to:

- Use basic programming skills,
- Establish and operate a quality control programme for the safe use of medical software,
- Establish the implementation of a medical device within the hospital IT system, and
- Test and accept software that is part of or connected to a medical device.

## 5.2 Radiotherapy

**Short description**
In a Radiotherapy department, a large amount of data is generated that must be rapidly available during and after treatment.

**Knowledge, skills and competences:**
The Radiotherapy MPE has knowledge of:

- Dedicated IT systems for Radiotherapy (such as systems for RT logistics and Record and Verify systems),
- Backup solutions for dedicated Radiotherapy IT,
- The role of AI in image generation, image reconstruction and image information,
- The role of AI in image segmentation and treatment planning, and

- The role of AI in treatment (outcome) prediction.

The Radiotherapy MPE Is able to:
- Establish a quality control programme for AI applications.

### 5.3 Radiology and Nuclear Medicine

**Short description**
Digital image communication, storage and distribution are increasingly relevant for the MPE. Images need to be transferred stored and accessed, but also connected with a patient's individual electronic health record (the Electronic Patient Dossier - EPD).

**Knowledge, skills and competences:**
The Radiology and Nuclear Medicine MPE has knowledge of:
- Data-compression techniques (lossless and lossy) and their potential image degradation effects, and
- Structured versus non-structured data in reporting results.

The Radiology and Nuclear Medicine MPE is able to:
- Write programs or scripts to handle data and to process and analyse images and DICOM headers, and
- perform software validation: dedicated workstations, server-client, different combinations of modalities and processing software

The Radiology and Nuclear Medicine MPE is competent to:
- Establish hospital-wide policies for image storage and routing.

### 5.4 General Medical Physics

**Short description**
Digital communication, storage and distribution is increasingly relevant to the General MPE. Images and data need to be transferred stored and accessed, but also connected with the patient's electronic health record (the Electronic Patient Dossier - EPD).

**Knowledge, skills and competences:**
The General MPE has knowledge of:
- The digitisation process, workflow and storage throughout the hospital,
- Data-compression techniques and their potential effects on image degradation
- Specific application of machine learning on image reconstruction, processing and analysis, and
- Software validation dedicated workstations, server-client, different combinations of modalities and processing software.

The MPE is able to:
- Write programs or scripts to handle data and to process and analyse images and DICOM headers.

### 5.5 Audiology

**Short description**
In audiology, data must be accumulated from various diagnostic devices and integration within the electronic patient file. The Audiology MPE is ultimately responsible for all (diagnostic) audiological data and the safe and secure representation of the data within the (electronic) patient file.

**Knowledge, skills and competences:**
The Audiology MPE is able to:

- Design of and advise on a safe representation of audiological data in the electronic patient files.

# 6. Organisation, management, finance, laws and ethics in healthcare

## 6.1 Common Trunk

**Short description**
The basic principles of healthcare finance, laws and medical ethics are an important framework for acting in a clinical setting. The MPE negotiates financial matters with the hospital directors, and health care insurance companies, and discusses ethical dilemmas.

**Knowledge, skills and competences**
The MPE has knowledge of:

- The structure of the national healthcare system,
- Financial aspects of the healthcare system, and health insurance,
- Hospital management,
- Departmental and/or hospital-wide financial plans,
- Purchasing policy and European tenders,
- Privacy legislation,
- National healthcare legislations (e.g., WGBO, WMO, Wet Medische Hulpmiddelen, wet BIG),
- Intellectual property regulations,
- Ethical considerations in medical research, and
- Medical Ethics Committees.

The MPE is able to:

- Prepare a business case for purchase of new equipment including the total cost of ownership, and
- Work as part of a team to purchase and install new equipment.

## 6.2 Radiotherapy

No additional requirements to common trunk.

## 6.3 Radiology and Nuclear Medicine

**Knowledge, skills and competences**
The Radiology MPE Is able to:

- Advise on preparation of a business case,
- Advise on preparation of a tender,
- Write a request for proposal for purchasing a new imaging device.
- Specify, justify and rank the criteria for selecting new imaging devices, and
- Negotiate with vendors.

**Deliverables**
During the training period, a resident is required to deliver at least the following items:

1. Visit the investment Advisory board of the hospital (if present).

## 6.4 General Medical Physics

No additional requirements to common trunk.

### 6.5 Audiology

**Short description**
In the Dutch healthcare system, the Audiology MPE is ultimately responsible for the audiological care provided to patients. It is the MPE's responsibility that the care the centre provides is in accordance with rules, regulations and guidelines. To this end they should understand various aspects of the national healthcare system and how audiological care is financed, be able to consider ethical aspects and have excellent communication skills.

**Knowledge, skills and competences**
The Audiology MPE has knowledge of:

- The relevant guidelines of the NVKF, FENAC and KNMG,
- The NOAH protocol,
- The restitution policy of insurance companies, and
- Finance of audiological healthcare.

The Audiology MPE Is able to:

- Take responsibility for the management and content of the care that is provided, which should be in accordance with the latest developments and with consideration for the financial aspects, and
- Maintain professional relationships with relevant care partners (such as hearing-aid dispensers and health care companies).

# IV. SCIENCE AND INNOVATION

**Short description**

The MPE plays a central role in science and innovation in medical technology. He or she is responsible for initiating innovations as well as performing and initiating scientific research. The MPE translates clinical problems into scientific questions and translates scientific results into clinical innovations. He or she can critically and objectively evaluate published research results. To prepare the MPE for these tasks, a research project is undertaken during the training programme, either as a full-time activity within a well-defined period or on part-time basis over a prolonged time period (e.g., part of the practical training period).

Research should be well structured, well defined and clinically relevant. Research should be performed under supervision of an experienced scientist, preferably in a multidisciplinary research group with regular research meetings and group presentations, in order to expose the resident to other research methods and topics.

Research should be carefully planned to identify a specific research topic and formulate a clear research question in the first year of the training. Essential steps such as approval of the Institutional Review Board, access to clinical data and availability of equipment should be met in the second year of the training. It is recommended that at the end of year three a scientific report is ready for peer review. Regular reporting of the progress of the research project(s) in the progress report is advised.

Note: many institutes have certain requirements when performing research (e.g. BROK, GCP).

**Knowledge, skills and competences**

The MPE has knowledge of:

- Ethical and privacy regulations for scientific research,
- Fundamentals of biostatistics and statistical tests,
- Computational techniques and software packages for statistical data analysis,
- Meta-analysis and medical big data studies, and
- Regulations on intellectual property.

The MPE is able to:

- Design a clinical or technical study to improve diagnostic and treatment techniques,
- Write an application for approval by the medical ethical committee,
- Review scientific literature,
- Design an experiment and collect data,
- Analyse and interpret experimental results,
- Evaluate the impact of innovative diagnostic and treatment techniques,
- Perform or analyse studies of patient outcomes (such as survival data, complication rates or patient reported outcomes),
- Present results from scientific research, and
- Report scientific results.

The MPE is competent in:

- Translating scientific results into clinical innovations, and
- Translating clinical problems into scientific questions.

**Deliverables**

1. Peer-reviewed paper as a first author or an oral presentation at an International Congress (with peer-reviewed abstract submission) as presenter. This is required by law, Staatsbesluit [6]. Also refer to “Praktische uitwerking van de eis tot wetenschappelijke vorming binnen de opleiding tot klinisch fysicus” on www.stichtingokf.nl

Total time to be spent: 60 ECTS.

# List of deliverables

## 1. Common (all subspecialisms)

**2.1 Physics and Engineering**

1. Perform an acceptance test/commissioning/calibration of a medical device.
2. Write a recommendation for development/adjustment of a medical device or procedure that is in clinical use.

**3.2 Risk Management, Quality Control and Safety in the Medical Environment**

1. Participate in a quality control program for a medical device or clinical procedure.
2. Analyse a recent incident in the department.
3. Perform a prospective or retrospective risk analysis for existing or new equipment or treatment technique.

**4.1 Radiation Physics, (Radiation) Protection and Dosimetry**

* Lines marked below with an asterix do not apply to –Audiology MPEs.

1. The national course for radiation protection expert (RPE, in Dutch: *Coördinerend deskundige*) should be successfully completed. The relevant (Dutch) course for the Audiology MPE is the Toezichthoudend Medewerker Stralingsbescherming – Medische Toepassingen.
2. At least one of the following items:*
   - Perform a radiation survey of an area using appropriate dose-rate equipment,
   - Study or perform practical design calculations for a room in which ionising radiation will be used,
   - Plan and practice contingency measures, such as for a lost radiation source or spill,
   - Discuss decontamination procedures after a spill of liquid radionuclide with practitioners or patients,
   - Join the local Radiation Protection Commission of your department or institute, or
   - Join the local medical ethics committee as an advisor on the use of ionising radiation in human research.

**IV Science and Innovation**

1. Peer-reviewed paper as a first author or an oral presentation at an International Congress (with peer-reviewed abstract submission) as presenter. This is required by law, Staatsbesluit [6]. Also refer to “Praktische uitwerking van de eis tot wetenschappelijke vorming binnen de opleiding tot klinisch fysicus” on www.stichtingokf.nl

# 2. Radiotherapy

**2.2.2. Treatment and simulation**

1. Make and analyse 20 treatment plans, equally distributed over all common target areas.
2. Analyse plans for potential pitfalls in delivery, such as overmodulation, collisions and anatomical changes.

**2.2.4. Brachytherapy**

1. Make five brachytherapy treatment plans.
2. Be present during the preparation and treatment for three patients, including presence at the operating room, to experience the complexity and the teamwork.
3. Be present at a source replacement by the company, perform a measurement of the source activity and import this activity in the TPS.

**3.2 Risk Management, Quality Control and Safety in the Medical Environment**

1. Participate in the incident management commission.
2. Perform acceptance testing and commissioning of a treatment unit or treatment planning system (this deliverable replaces the first deliverable at 2.1).

**4.2 Radiation Physics, (Radiation) Protection and Dosimetry**

- Participate in an external dosimetry audit.

## 3. Radiology and Nuclear Medicine

**6.3 Organisation, management, finance, law and ethics in healthcare**

1. Visit the investment Advisory board of the hospital (if present).

# 4. General Medical Physics

**2.4 Physics and Engineering in Medicine**

The resident is required to deliver at least the following items:

1. Participate in the building design process for new equipment,
2. Participate in solving artefacts,
3. Participate in image protocol optimisation for at least one type of medical equipment, and
4. Perform image quality measurements for at least two types of imaging equipment. The resident is required to take a leading role in at least one of these projects.

**3.4 Risk Management, Quality Control and Safety in the Medical Environment**

During the training period, a resident is required to deliver at least the following items:

1. Write (or rewrite), implement and follow-up (Plan-Do-Check-Act - PDCA) at least one local guideline on quality management or closely related item,
2. Perform or participate in at least one audit or safety check of a department in which a lot of medical equipment is used,
3. For a minimum of three devices or groups of devices, a General Medical Physics resident should:
   - Compose a complete business case or compose a request for proposal, or,
   - Compose, set up and perform an acceptance test, or,
   - Provide training to physicians, nurses or technicians for at least one type of medical equipment,
4. The resident is required to take a leading role in at least one of these projects. The devices included in Deliverable 3 should include, as a minimum, one device from each of:
   - Radiology or nuclear medicine,
   - The operating room or intensive care unit, and
   - Functional monitoring (for example, cardiology or audiology).

**4.4 Radiation Physics, (Radiation) Protection and Dosimetry**

1. Perform or participate in three procurement trajectories (including procurement, installation and implementation) of new medical radiological equipment or a radiopharmaceutical laboratory device).
2. Set up at least one training programme on medical radiological equipment to users.
3. Perform calculations regarding shielding (for at least one radiological used room).
4. Compose or assist in composing a permit application for radiation protection (in dutch Vergunningsaanvraag ANVS).

# 5. Audiology

**1.5 The Patient**

In audiology, each resident has to show to be able to conduct all of the above-mentioned skills in a system of multiple Entrusted Professional Activities (EPAs), comprising different categories of audiological care. These EPAs are:

1. Hearing diagnosis in adults,
2. Hearing rehabilitation and audiological care in adults (mainly via hearing aids or bone conduction devices),
3. Hearing diagnosis in children and infants,
4. Hearing rehabilitation and audiological care in children and infants,
5. Cochlear implants in adults,
6. Cochlear implants in children and infants,
7. Vestibulology,
8. Speech and language development in children, and
9. Tinnitus

All these EPAs are addressed throughout the four years of training within the standard clinical care of the training institute, using different levels of supervision, working from supervision level 1 to 3, 4 or 5, depending on the EPA.

**2.5 Physics and Engineering in Medicine**

1. Calibrate and deliver a calibration report on an audiometer. (replaces 2.1 Common Trunk, first deliverable).
2. Each Audiology resident must demonstrate the ability to conduct all of the above mentioned skills in a system of multiple EPAs, comprising different categories of audiological care. The EPAs are addressed throughout the four years of training within the standard clinical care of the training institute. These EPAs are described in more detail in section I.5.